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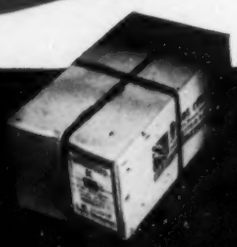

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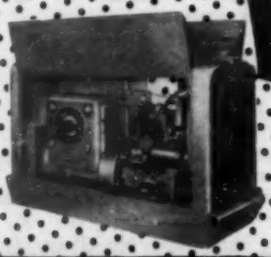

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Assembly of Structural Columns in Rigid Jigs. *Courtesy Pittsburgh Bridge & Iron Works.*

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The Journal of
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Quantity Production of Railroad Passenger Cars by Resistance Welding*

By A. M. Unger†

DUE to the increased demand for railroad passenger cars, the Pullman-Standard Car Manufacturing Co. has installed an enlarged resistance welding setup for producing cars in quantity production. Roofs and sides for the cars are being made in large spot-welding fixtures that handle full-sized, car-length sections. Subassemblies of stiffeners to side sheets for the cars are being made on a multiple electrode machine with a large table that automatically indexes the work under a row of spot-welding electrodes. These enormous jigs insure correct alignment and a minimum amount of distortion in addition to an accelerated speed of production. Each of these machines will be described in detail. They are all made as fully automatic as possible thereby giving high-quality results with a minimum of labor costs. These machines are set up for operation by the welding Engineering Department and do not require any great amount of welding knowledge as far as the operators are concerned.

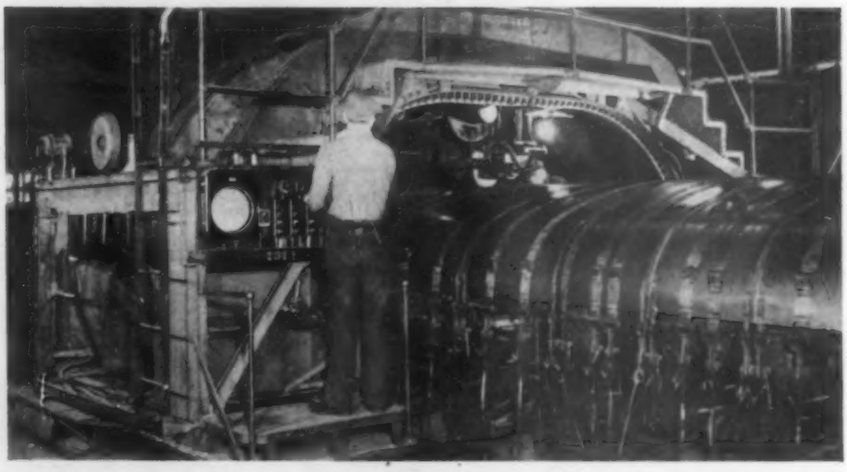

Fig. 1—Spotwelding Railroad Passenger Car Roof Sheets to Carline with Roller Electrodes

Roof Machine

Roofs for the railroad passenger cars are welded in the machine and jigs shown in Fig. 1. This machine has roller-type electrodes that are mounted on a carriage that traverses the entire length and width of the roof jig. The track for the transverse movement across the roof is shaped to conform with the curvature of the roof so that welding pressure in all positions is normal to the roof. Two electrode rolls are used side by side connected in series with the welding transformer so as to make two welds simultaneously, one on each of two sheets that butt together on the roof carline. The roof carline is supported by a copper back-up bar, which in turn is supported by a steel structure capable of withstanding the pressure of the two welding rolls.

Figure 2 is a sketch illustrating the path of welding current through the electrode rolls, work and copper back-up bar. As the rolls move along the carline, current is applied intermittently so that a definite spacing of spot welds is produced. A cotton string is placed in between the edges of the two sheets to serve as insulation and prevent the welding current from shunting across from sheet to sheet.

Movement of the welding rolls along the carline is controlled by a variable speed, d.-c. motor driving the welding unit. The welding rolls are idlers, their speed being governed by the speed of the welding unit. This is a direct ratio only when the welding unit is running on a straight track and the welding rolls are on a straight line parallel to the track. The track, however, is not straight but curved, and the roof also has a varying curvature. In order to have constant welding speed at the electrode rolls it is necessary to vary the speed of the driving motor. This is accomplished by obtaining power for the driving motor from a M.G. set. The voltage supplied to the driving motor is varied by means of a rheostat in series with the shunt field of the d.-c. generator of the M.G. set. The rheostat is mounted on the welding unit and is operated by a cam track placed along the supporting track of the welding unit. By proper location of the cam track, it is possible to have constant speed at the welding rolls. At certain positions on the roof, however, it is desirable to have a change in welding speed to compensate for the variation in contact area of the welding rolls to the work on those portions of the roof with different radii of curvature. The top of the roof has a much larger radius than the sides (Fig. 3); therefore, more of the roof sheet is in contact with the electrode roll. It is necessary to speed up the welding roll on that portion of the roof with the smaller radius in order to avoid overheating of the spot welds due to the higher concentration of welding current. It has been found very practical to do so on this machine, thereby producing uniform welds.

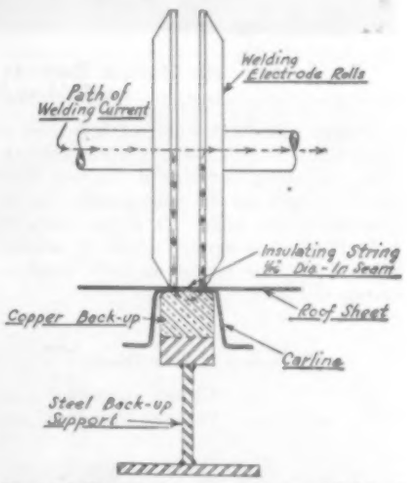

Fig. 2—Sketch Showing Series Weld of Roof Machine—Two Welds at One Time

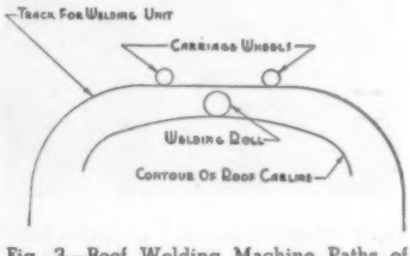

Fig. 3—Roof Welding Machine Paths of Carriage Wheels and Welding Rolls

* Scheduled for Twenty-Seventh Annual Meeting, A.W.S., Atlantic City, N. J., week of Nov. 17, 1946.

† Welding Engineer, Pullman-Standard Car Manufacturing Co., Chicago 28, Ill.

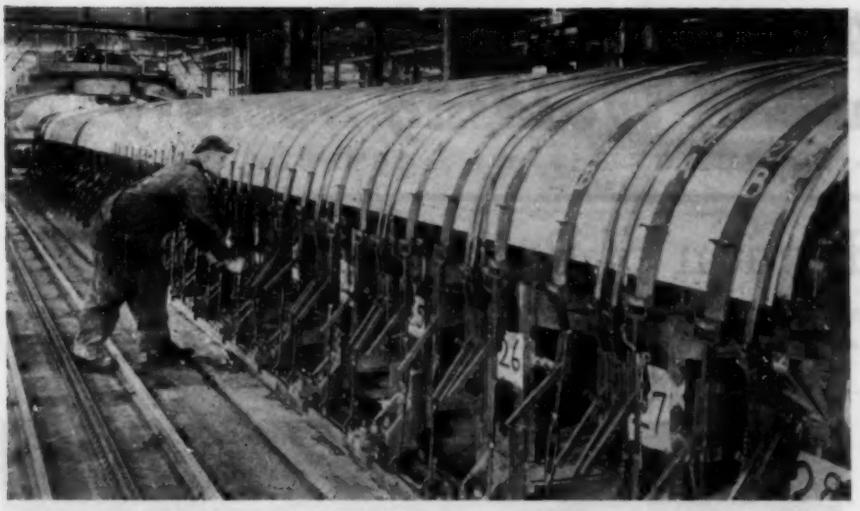

Fig. 4—Clamping Roof Sheets to Jig

Fig. 5—Automatic Multiple Electrode Spotwelding Machine with Movable Table for Welding Side Sheet Stiffeners

Figure 4 illustrates the method used to strap down the roof sheets while welding. The heat along the edge of the roof sheet tends to open up the joint due to the expansion of the edge. It is necessary to hold the sheets firmly. This is accomplished by four straps on each sheet as shown in Fig. 4.

Stiffeners to Side Sheets

Flat sides on railroad passenger cars spot welded at Pullman-Standard are accomplished by the use of internal stiffeners spot welded to the side sheets. The entire area of the side with the exception of clearances for attachment of framing members is covered with corrugated stiffeners. These stiffeners prevent any distortion or buckling of the side sheets. There is a considerable amount of spot welding involved in the fastening of these stiffeners to the side sheets. A large multiple electrode machine with an indexing table has recently been installed to weld these subassemblies in large quantities. This machine is illustrated in Fig. 5. This machine also utilizes the series welding principle. Two electrodes are in series, with the copper plate on the table top serving as a back-up, underneath the work, to conduct the welding current. Each pair of electrodes has a separate welding transformer. Spacing between the electrodes is adjustable. Figure 6 is a close-up of the welding electrodes in position over the work. Each electrode has individual pressure adjustment by means of springs.

Fig. 6—Adjusting Pressure of Electrodes on Multi-Spot Machine

All the electrodes are mounted on a ram, the vertical movement of which is toggle operated by means of hydraulic cylinders. Provision is made for a normal operating stroke and an additional retraction stroke to clear higher objects.

The main feature of this machine is its automatic operation in indexing and movement on the table. The table is made twice the length required for the work so that one end can be unloaded and loaded while welding is taking place on the other

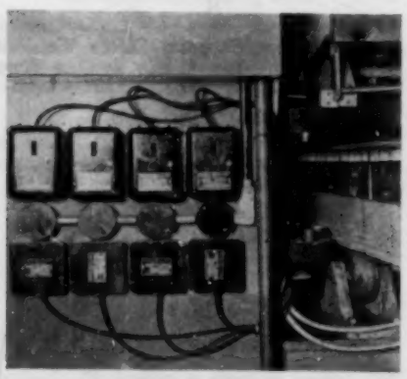

Fig. 7—Photo-Tubes and Controls for Automatic Indexing of Work Table on Multi-Spot Welding Machine

Fig. 8—Setting Indexing Pattern for Multi-Spot Machine

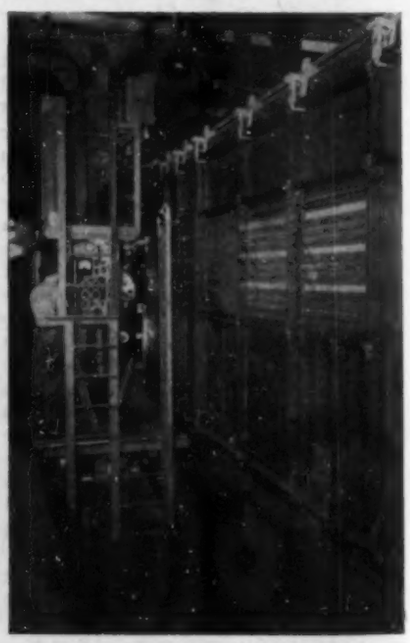

Fig. 9—Automatic Side Spotwelding Machine

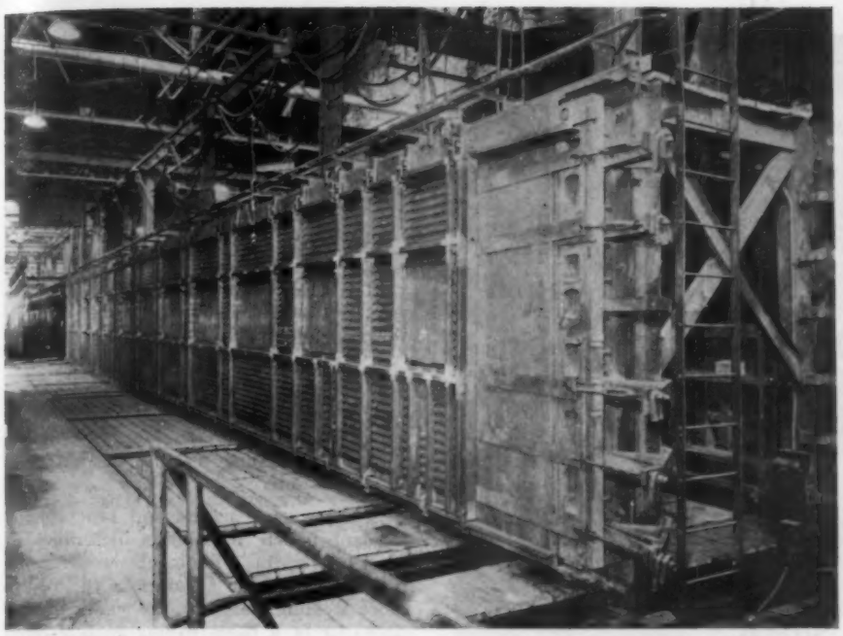

Fig. 10—Side Spotwelding Back Up Jig Showing How Full Length Side Is Fitted in Position for Welding

end. Indexing is accomplished by means of phototube relays. This equipment is shown in Fig. 7. The light sources and phototubes are mounted near one side of the table so that an indexing pattern on the table will control them. Figure 8 shows the indexing pattern being set up. Two rows of holes full length of the table are placed in such a position as to pass between the phototube and light source. All holes are filled with loose rivets so that light cannot pass through. When a rivet is pulled out of a hole, it permits light to pass through, operating the phototube relay and welding in the position selected. Any pattern of welding desired can very easily be set up. The second row of holes controls retraction of the electrodes. By selecting the proper rivet to pull out of the hole, the electrodes can be made to retract in any desired position. The table is automatically controlled so that, if desired, it will upon finishing the work on one end of the table, automatically move to the center and start welding on the work that has been loaded on the other end of the table.

Side Machine

Sides of the railroad passenger car are spot welded with an automatic machine of the type shown in Fig. 9. The work is capable of resisting pressure of the electrodes anywhere over its surface. The full side of a car is fitted up at one time as shown in Fig. 10. Four such fixtures are provided. Welding is performed on two of the fixtures, while the other two are being unloaded and loaded. Three machines are provided and a suitable number of controls so that two machines can weld simultaneously on any one of the fixtures desired.

The spot-welding machine has a welding unit that consists of transformer, electrodes and air cylinders. This unit runs up and down vertical guides and is indexed automatically by means of an electronic sequence panel. The welding unit is rotated 90° for welding horizontal members of the framing to the side sheets. When welding horizontal rows the entire machine indexes along the track on which the machine is mounted. Indexing of the machine is accomplished by means of a motor which is started and stopped for each index. The length of time that the motor runs is governed by a sequence panel. Spacing of the spots is controlled by turning a dial on the sequence panel. A plugging relay gives quick braking for the motor and accurate spacing. The motor is especially designed for frequent starting.

Two electrodes which are connected in series with the welding transformer pass current through the work and the copper back-up plate, thereby making two welds at every operation. These electrodes are shown in Fig. 11. Movement of the electrodes in and out and starting of the weld-

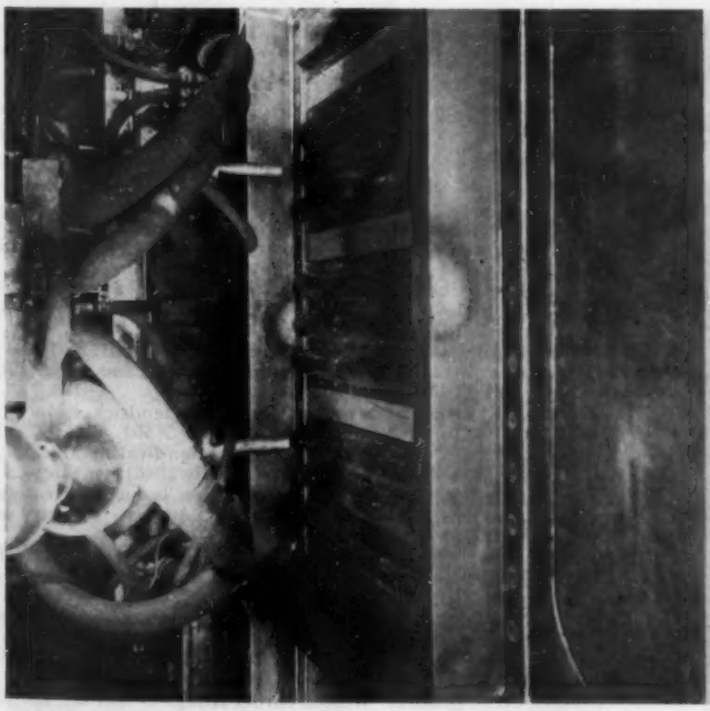

Fig. 11—Close Up of Electrodes on Side Spotwelding Machine

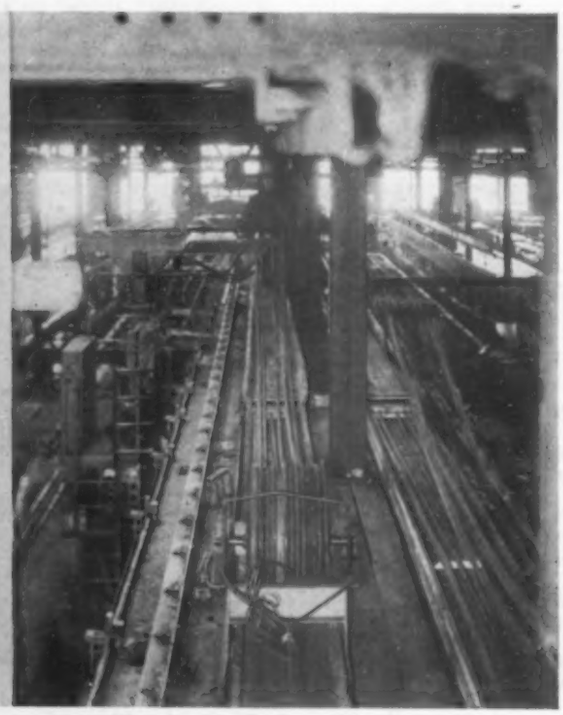

Fig. 12—View on Top of Side Spotwelding Machine Showing Method of Bringing Air, Water, Welding Power and Control Cables to Machine Traveling Full Length of Two Railroad Car Sides

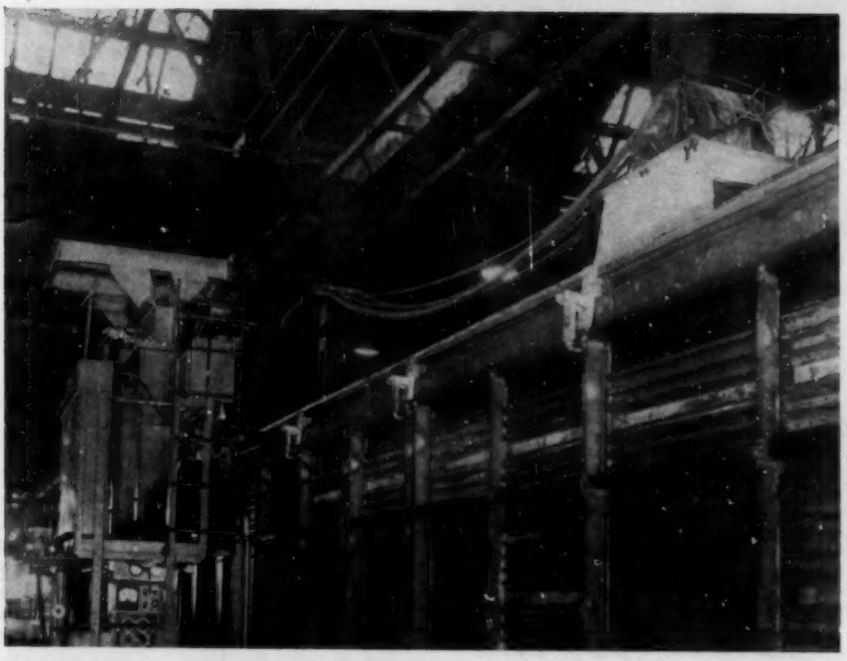

Fig. 13—View Showing Supply and Control Cables to Side Spotwelder from Another Angle

ing current are controlled by an electronic sequence panel.

Power, Water and Air Supply

The roof and side machine move along tracks that are over twice the length of a railroad car. Welding power, control, air and water lines must connect to the machine at all positions. This becomes quite complicated when about 40 control wires, in addition to power cables, and water and air hoses are involved. The method used to solve this problem and supply these services to the side machine is shown in Figs. 12 and 13. All of the leads are brought up in the center of the jig and pass around sheave wheels on a movable carriage and then to the welding machine. A counter weight is attached by means of a cable to the sheave carriage. This serves to hold the carriage as far from the welding machine as the length of the leads will permit, thereby keeping slack out of these cables and hoses at all times.

Controls

The three machines described all have electronic controls that perform the following functions:

1. Sequencing of operations
2. Indexing of welds.
3. Timing of welding current.
4. Interruption of welding current.
5. Maintaining welding current constant.

The sequence panels and synchronous control panels have been described in various papers. Phototube control for indexing of welds is novel in the resistance welding industry, especially in the indexing of a table having such a large mass. The electronic current compensator has been found to be a very useful instrument. Remarkable consistency in welds is produced by the use of this control that compensates for line voltage variations and impedance variations in the welding current.

Subassemblies

Standard single spot type machines are used in miscellaneous subassemblies such as stiffeners to roof sheets, battery boxes, partitions, cabinets, lockers, etc.

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(*Continued on page 935*)

How to Select Wear-Resisting Alloys for Welding*

By Joseph A. Cunningham†

CLASSIFYING hard-surfacing electrodes is difficult since (*a*) wear resistance is not directly proportional to the hardness of the weld deposit, (*b*) newer methods of manufacturing hard surfacing have crept into the picture—namely, by adding hardening ingredients in electrode coatings instead of the core rod.

Ten factors should be considered when choosing hard-surfacing electrodes or rods: (1) severity of abrasion, (2) type of impact (if any), (3) rewelding worn hard-surfacing deposits (if necessary), (4) size of part to be surfaced, (5) thickness of deposit required, (6) composition of base metal, (7) work hardening encountered after welding, (8) corrosion (if any), (9) heat present or created (if any), (10) subsequent heat treatment or machining after welding (if necessary).

The proper selection of hard surfacing is closely related to severity of abrasion involved. For example, if the part to be hard surfaced is known to have lasted two to three years,[1] then an inexpensive hard surfacing should be selected because by and large almost any hard surfacing will last longer than the original nonhard-surfaced part.

If the part wears out quickly, and if only a small amount of hard surfacing is required for rebuilding—that is, if the wear is severe and concentrated on a small area, such as on the point of a plow share (see Figure 1) or scarifier tooth, then the best grade available should be selected, because the amount of hard surfacing required is small and the cost of material is not a major factor. Also, if many man-hours are required for disassembly, and if the shutdowns due to repairs are costly, the best hard surfacing that will properly do the job is the most economical.

Severity of Abrasion

Abrasion can be considered as twofold: (1) Sliding abrasion, i.e., abrasion resulting from a mass of material sliding over another, e.g., sand slipping past an agitator paddle; wire passing through guides in a steel mill, etc. (2) Rolling abrasion, e.g., crane wheels rolling over crane rails; gear teeth meshing against each other, etc. These two types of wear call for different hard surfacings[2]—sliding abrasion requiring a hard wear-resistant alloy and rolling abrasion requiring less wear resistance but usually a tougher alloy. To resist sliding abrasion, choose a hard alloy in which the hard particles are imbedded in a tough-hard matrix. To resist rolling abrasion, the matrix between the hard particles need not be especially wear resistant.

As a further explanation, to withstand severe sliding abrasion, choose either of the following: (*a*) A cast hard surfacing instead of a drawn one,[2] or one which will produce a like deposit, that is, one of the harder groups usually containing carbon ranging from 2–3½% in the weld deposit.[3] (*b*) A composite hard surfacing composed of synthetic crystals, borides, carbides, etc., held in a tube, frequently referred to as tube metal. Composite hard surfacings, as-welded, should contain a tough-hard matrix which will not wash away and leave the hard protruding particles unprotected, and hence subject to shear breakage. Recapitulating, to resist sliding abrasion when wear is concentrated on a small area, choose a composite hard surfacing with tiny hard particles held in place by a tough-hard matrix. To resist sliding abrasion on large areas, choose a cast hard surfacing or one which produces a deposit having high carbon and considerable alloy present.

Type of Impact

Impact may be considered in two groups: (1) edge impact or heavy compression. Edge impact might be compared to the impact on the edge of a chisel (Fig. 2).

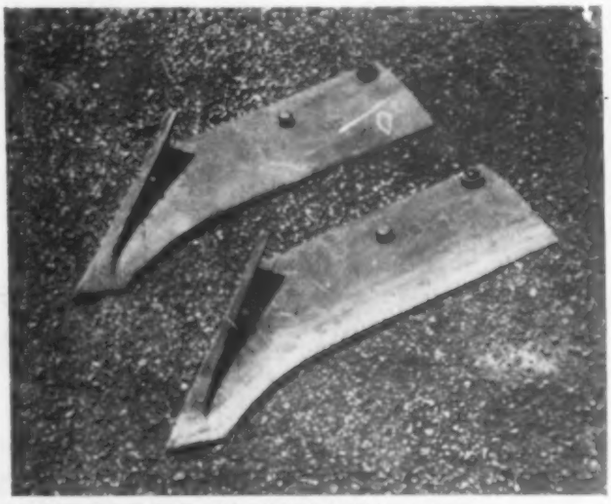

Fig. 1—Hard-Surfaced Plow Share

Lower view shows new share hard surfaced with a relatively expensive rod capable of resisting both severe abrasion and moderate edge impact. Since only a small amount is required and wear takes place on a concentrated area, choose the best alloy that will do the job.

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[1] Frequently new parts should be hard surfaced before putting them into service, also rapidity of wear can be estimated and the hard surfacing selected accordingly.

[2] Many large hard-surfacing manufacturers today do not make cast electrodes but achieve the same results in a satisfactory manner by using a carbon steel core wire and mixing alloy ingredients and carbon in the coatings to give the same effect in the weld deposit.

[3] Extreme hardness may be obtained from ingredients other than high carbon such as boron, etc.

Composition	RESISTANCE TO							Applied By	HARDNESS		Tensile Strength, Psi.	Elongation, %	R. A., %	Uses	Price per Pound
	Abrasion (1)	Erosion	Corrosion	IMPACT		Heat	Thermal Shock		Rockwell C	Brinell					
				Flat	Edge										
Diamond hard synthetic granule and alloys in steel tube. Bond composition: Chromium.. 30% Moly..... 8% Cobalt..... 8% Boron..... 0.05% Tungsten... 5% Carbon.....0.20%	0.10	E	F	E	E	E	E	O-A	Granule 0.98 Bond 60	Granule 1600 Bond 0.610	Granule 300,000 Bond 200,000	Granule None Bond 15%	Granule None Bond 8	Extreme wear resistance. Coal-cutter bits, grader blades, scarifier teeth, shovel teeth, plow shares, conveyor screws, dredge heads, fish tail bits, rock and roller bits.	Oxyacetylene only All sizes $6.50.
35% Tungsten 16% Moly. 3% Cobalt 0.05% Boron 0.10% Carbon	0.20	F	G	E	G	E	G	Arc	65	675	225,000	Nil	Nil	High resistance to wear, heat, shock.	1/4 in.....$4.50 5/16 in..... 4.50 1/8 in..... 5.40 Not recommended for oxyacetylene.
Nonferrous chrome-moly. and copper crystals. Chrome.....35% Moly..... 5% Crystals..... 60% Crystal Size—1 micron.	0.25	E	E	E	F	G	G	O-A Arc	59 58	600 590	100,000	Nil	Nil	Excellent wear, corrosion and heat resistant. Plows, grinding rings, screw conveyors.	5/16 in.....$1.75 1/4 in..... 1.90 5/16 in..... 2.00 5/32 in..... 2.75 1/8 in..... 2.75 Deduct 25c per pound for oxyacetylene rod.
Chrome.... 35% Moly..... 10% Tungsten... 8% Cobalt..... 6% Copper..... 14% Boron..... 0.02% Carbon... 0.60%	0.25	E	E	E	E	E	E	O-A Arc	58 56	590 560	115,000	3%	Slight	Special alloy for all valve faces. Automobile, Diesel, airplane, high pressure steam, poppet, blow down, plug and gate, corrosive liquid.	5/16 in.....$3.50 1/8 in..... 4.00 For oxyacetylene, atomic - hydrogen, helic-arc or arc welding.
High chrome, low moly. with boron and titanium in iron base. Carbon.....0.20%	0.35	F	F	E	E	F	E	O-A Arc	56 55	540 540	185,000	2%	35	General purpose, shock and abrasion forgeable, self-hardening. Dipper teeth, tractor sprockets, etc.	1/4 in.....$0.60 5/16 in..... 0.60 3/32 in..... 0.58 1/8 in..... 0.65 3/32 in..... 0.75
15% alloy with chrome, moly., nickel and boron in an iron base. Carbon.....2%	0.45	F	F	G	F	-	-	O-A Arc	57 55	575 550	70,000	Nil	Nil	Outstanding low cost value for abrasion.	Coated. Shape—round. 5/32 in.....$0.42 1/4 in..... 0.45 5/16 in..... 0.47 Deduct 8c per pound for bare rod.
Special wear-resistant alloy for Two-Tone process only. Analysis: Chrome.... 12% Moly..... 2% Nickel..... 8% Boron..... 1% Titanium..... 4% Carbon..... 4%	0.50	F	F	G	F	-	-	Spec. Arc only "Two Tone"	54	540	60,000	Nil	Nil	Used with a mildsteel electrode type A.W.S. E6010, E6011 in the Two-Tone process.	Bare, round, cast. 5/8 x 24 in....$0.25 1/4 x 24 in.. 0.30
Special drawn steel wire for use in the Two-Tone process only. Analysis: Chrome.... 4% Nickel..... 6% Moly..... 2% Vanadium.. 3% Boron..... 0.5% Carbon.....1.25%	0.80	-	-	E	G	-	G	Spec. Arc only "Two-Tone"	45 to 50	450 to 500	75,000	Slight	2%	For rapidly depositing a high-grade, semi-ductile, high-carbon layer of metal in build-up of high-carbon steel parts of heavy machinery by "Two-Tone" process only.	Bare, round, drawn rod. 5/8 x 24 in....$0.55 1/4 x 24 in.... 0.60
Special cast nickel-manganese filler rod for Two-Tone process only. Manganese 30% Nickel..... 10% Vanadium.. 2% Carbon.....1.75%	0.45	G	G	E	E	F	F	Spec. Arc only "Two-Tone"	25 to 58*	250 to 585*	70,000	* See Note	* See Note	Abrasion with impact for rapidly and economically building up all cast and rolled nickel-manganese steels on shovel teeth, tractor treads, bucket lips, etc., by the Two-Tone process.	Bare, round cast. 5/8 x 24 in....$0.55 1/4 x 24 in.... 0.60

E = excellent; G = good; F = fair; - = not outstanding; * = after work hardening.

Flat impact is herein defined as a blow perpendicular to a flat surface. Edge impact is that type of impact normal to an edge or corner, e.g., on the edge of a cold chisel, shear blade or rail end. Extremely heavy pressures or extra heavy blows applied in any direction should be considered as having the same effect as edge impact.

1. Abrasion factor is the approximate rate at which the deposit wears off due to abrasion compared to a mild steel abrasion factor = 1.00.

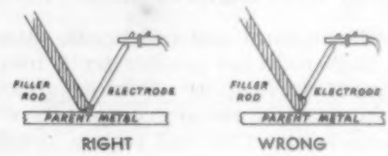
* Deposits are soft when deposited but after impact harden exactly like straight manganese cast steels or nickel content drawn or rolled manganese steel.

HARD FACINGS

Appearance Color—Code Marks of Rods	Welding Characteristics	Amperes for Welding	Is Deposit Forgeable?	Response to Heat Treatment and Machinability	Increase in Hardness Due to Cold Working
Synthetic granule equally as hard as the white diamond secured in a specially alloyed tube containing definite proportions of chrome, moly., cobalt and boron metal powders which alloy with tube metal to form a very tough hard bonding to hold granule in place for work. 60*100 screen-nickel tube. 20*40 screen-copper tube.	Apply with oxyacetylene torch—deposits are fluid and bond to parent metal readily. Larger sizes can be used in the "Two-Tone" process with E6010 live electrode to obtain an extremely abrasion-resistant surface.	Oxyacetylene flame should be slightly carbonizing (excess acetylene). For "Two-Tone" process increase amp. 30% and use in conjunction with E6010 rev. polarity electrodes, E6011 or E6020 electrodes.	Yes—But forging has tendency to drive or bury particles into parent metal.	None	None
Particles in copper-coated steel tubes. Bare or with brown coating—green tip. Code—Green Tip.	Use reverse polarity d. c. or a. c. Apply in beads up to 3/4 in. wide. Use high amperes and hold long arc.	1/4 in.....200 to 300 5/16 in.....150 to 250 1/2 in.....100 to 150	No	Cannot anneal. Cannot machine.	Negligible
Cast. Black coating or bare. Code—Red Tip.	Use reverse polarity d. c. or a. c. Apply in beads up to 1 in. wide. Easy to use. Easy to apply with acetylene using decidedly carbonizing flame.	5/16 in.....250 to 350 1/4 in.....190 to 275 5/32 in.....150 to 225 1/8 in.....80 to 130 Oxyacetylene. Use decidedly carbonizing flame.	Difficult	Cannot anneal. Cannot machine.	20 Brinell
Oxyacetylene—Cast. Ground finish. Code Color—Brown. Electrode—Cast. Dark Gray Coating. Code Color—Brown	Use reverse polarity d. c. or a. c. —apply in beads 1 in. wide or less. Oxyacetylene—flows very freely with neutral flame. No flux required on steel.	Oxyacetylene. Use neutral flame. Electrode Amp. 5/32 in.....150 to 190 1/8 in.....80 to 120	Difficult	Cannot anneal. Machinable with difficulty, use carboloy or kennametal tool. Grinding is best.	20 Brinell
Drawn wire. Yellow tip for electric welding. White tip for acetylene welding. Both are black coated.	Use reverse polarity d. c. or a. c. Can be applied with a wide weave in vertical position. A mineral-coated rod is used for acetylene welding.	1/4 in.....180 to 260 5/16 in.....140 to 190 3/32 in.....115 to 160 1/8 in.....80 to 130 5/32 in.....40 to 90	Yes	Cannot anneal.	30 Brinell
Cast. Black coating or bare. No color tip.	Use reverse polarity d. c. or a. c. Apply in beads up to 1 in. wide. Coated rod can be applied in vertical position. Oxyacetylene—use neutral or slightly carbonizing flame, flows freely.	5/16 in.....240 to 340 1/4 in.....190 to 300 5/16.....150 to 225 Increase amperage slightly for bare Flintype VH.	No	Not practical to anneal. Cannot machine.	Negligible
Cast—Dark gray rod. Color Code—Orange both ends. Rod—24 in. long.	Designed as a filler rod for use by the Two-Tone process only. Use with E6010, E6011, E6020 or E7010 heavy coated electrodes as source of heat. *Use reverse polarity* or a. c. on E6011 and E6020 electrodes. Increase amperage 30%.	3/8 in. rod—use 1/4-in. or 5/16-in. live electrode. 1/4-in. rod—use 5/16-in. live electrode. Do not apply with carbon arc.	No	Not practical to anneal deposits. Cannot machine.	Negligible
Drawn wire. Color—Grayish-brown. Rod—24 in. long. No color tip.	Designed as a filler rod for use by the Two-Tone process only. Use with E6010, E6011, E6020 or E7010 heavy coated electrode as source of heat. Increase amperage 30% over normal.	Same as above.	Yes	Can anneal, machine and subsequently re-harden.	Negligible
Cast—Light gray to bright nickel color. Color Code—Blue—both ends. Rods—24 in. long.	Designed as a filler rod for use by the Two-Tone process to give high quality nickel-manganese steel, deposits of austenitic type. Use E6010, E6011 electrodes for best results as source of heat. Increase amperage on the electrode 30%—work fast.	Same as second above.	Not ordinarily. Deposits should be peened while hot but only about 1/4 as much as regular nickel-manganese steel deposits.	Cannot anneal. Cannot machine. Deposits are the same as high-grade nickel-manganese steel of the austenitic type. 3 1/2 to 5 nickel. 11 to 14 manganese.	250 Brinell Deposits impact harden like best grades of these steels.

Mistakes in Applying "Two-Tone"—and How to Correct Them.—Do not feed in too much of the alloyed filler rod into the arc as this produces over-roll and decreases penetration which will result in spalling or flaking off of the weld metal. The welding electrode must be kept near the work (hold medium arc) just as though the "dead" rod were not being used. The electrode is tilted in the opposite direction than for ordinary welding so that a very small portion of the arc—15 to 30% of it—nips the edge of the filler rod. Use 30% excess amperage.

Two-Tone Welding



RIGHT WRONG

Heavy compression might be compared to the impact encountered on a railroad track. These two conditions in group 1, i.e., edge impact and heavy compression, while widely different in nature, require approximately the same toughness in a hard surfacing. Group 2, flat impact. Flat impact implies to a blow without accompanying heavy compression normal to a surface such as might be encountered between a cement mill roll and die ring where the crushing force is normal to the die ring but the load is never tremendously large. Another example of flat impact would be very coarse gravel containing rocks passing through a large pump shell casing. In these instances of flat impact there is no concentrated wear or impact on the edges—neither is there extremely heavy compression. To resist flat impact when severe abrasion is present, choose a cast electrode or one with great hardness and wear resistance (Fig. 3).

To resist edge impact, choose a hard surfacing with a high tensile strength. This will generally necessitate selecting a drawn hard surfacing and one which will contain less than $1^1/_2\%$ carbon in the weld deposit. Obviously, when the carbon content in the rod is in excess of $1^1/_2\%$, the hard surfacing must be cast, since it is not

Fig. 2

Coal-breaker hammers are subjected to impact and severe abrasion on the tip. Hence, it is advisable to build up initially with a tough-hard electrode and cap the point with a hard wear-resisting electrode.

practical to draw, roll or extrude steel with excessive carbon. This point can be illustrated by smashing the end of a cast hard-surfacing rod with a hammer and then flattening the end of a drawn hard surfacing with a hammer. As everyone knows, the drawn rod will spread out while the cast rod will not flatten out but will shatter. Hence, for severe edge impact or heavy compression, choose a drawn hard surfacing—however, do not choose a drawn hard-surfacing electrode with excessive hardening alloys and high carbon added in the coating. See footnote 3.

Rewelding Worn Surfaces (Impact Involved)

Cement mill die rings and roll heads, quarry shaker screens and large roll-type crusher teeth frequently require subsequent applications of hard surfacing before the original layer or layers are completely worn away. Figure 3 shows a part that will require rewelding over

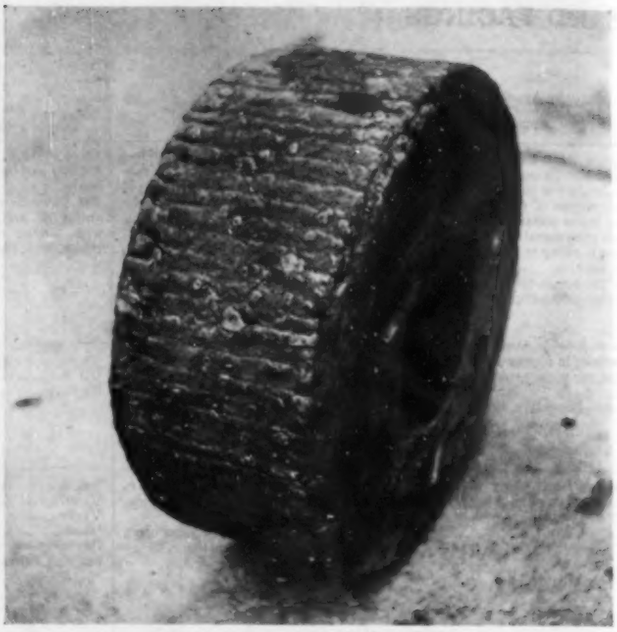


Fig. 3—Cement Mill Roll Head

Three such rolls are centrifugally rotated in the flat position against the inside of a large die ring to grind cement clinker. This exemplifies flat-impact and severe abrasion. Hence, choose a hard surfacing which resists abrasion and one in which the carbon does not exceed $2^1/_4\%$ so that re-welding over the worn surfaces does not cause a hard brittle zone between the hard-surfacing layers. Also the tensile strength of such a hard surfacing must be great enough to prevent spalling. Though this roll is cast iron it can be hard surfaced, if the heat from welding is distributed about the periphery by skip welding.

worn areas. Figures 1 and 4 show examples of why rewelding will not take place. Also, often two layers are applied originally, one superimposed over the other. It has been found that if too much carbon is present in the deposit, a second layer of like material superimposed over the first may cause some of the carbon to precipitate out of the solution and form a brittle carbide between the layers. This condition is not noticed until one-third to two-thirds of the first layer is worn away. Then if any impact is encountered, spalling occurs, i.e., one layer shells off in spots at the fusion zone between layers. Spalling[4] can be minimized by selecting an

[4] With hard-surfaced parts that are not too large to handle, cracking and subsequent spalling can be minimized by preheating, postheating or immediate immersion after welding in powdered asbestos, wood ashes or lime. If the product has been acetylene welded and therefore absorbed considerable heat frequently it can be immediately immersed in the slow-cooling medium after welding without applying additional external heat.

Fig. 4—Pug Mill Knives Used in Brick Manufacturing

Excessively worn parts can be restored by welding thin mild steel strips to worn-away spots and hard surfacing with multiple layers of alloy which resist severe abrasion and moderate edge impact. Severe impact is not encountered because clay does not contain coarse rocks, etc.

electrode in which the carbon content in the weld deposit is $2^1/_4\%$ max. Hardness and wear resistance can be obtained through the addition of other elements, or by using a hard-surfacing electrode composed of synthetic crystals imbedded in a tough-hard matrix.

Spalling may also be due to the selection of a hard surfacing too low in tensile strength, i.e., without sufficient strength to resist the battering that takes place, e.g., in a cement mill. Also spalling may result from the use of a hard surfacing without adequate tensile strength to resist the combination flexing and pounding encountered on quarry screens, etc. For example, ordinary gray cast-iron rods applied with the arc produce a hard wear-resisting surface, but the tensile strength is not high enough to resist shock, and rewelding over worn gray iron deposits causes a brittle zone between layers. The answer is to select a hard surfacing in which the tensile strength is great enough to withstand job conditions and one which does not contain excessive carbon.

Size of Part to Be Surfaced in Relation to Size of Electrode

When a quantity of electrodes is necessary to complete a job, the size of electrode is important because frequently the cost of labor and overhead amounts to more than the cost of the material. The deposition rate of a $^1/_4$-in. electrode is approximately 7 lb. per hour arc time, twice that of a $^3/_{16}$-in. electrode, which is approximately $3^1/_2$ lb. per hour arc time. Hence, larger electrodes cut down on labor, and in addition the larger cast electrodes are less costly than smaller ones.

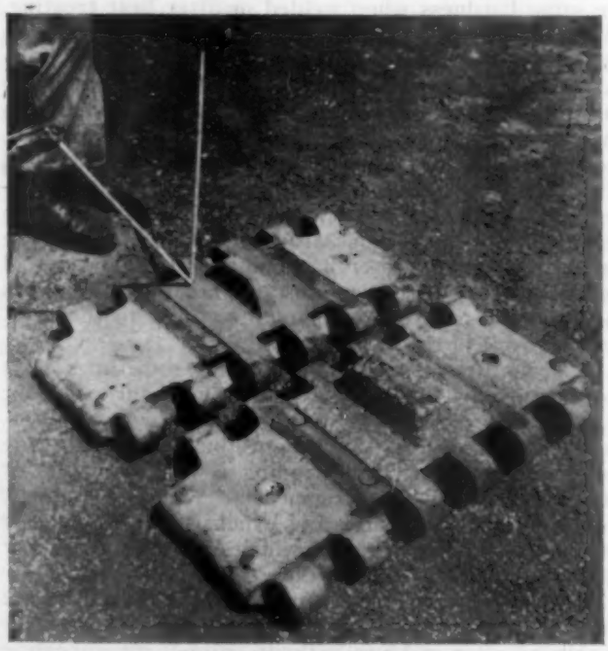


Fig. 5—Two-Tone Welding

Lower view shows section of power-shovel tracks hard surfaced by Two-Tone welding, a fast process used to restore original dimensions on large areas.

For hard surfacing large areas, Two-Tone welding[5] has gained favor (Fig. 5). Two-Tone welding consists of using a $^7/_{32}$-, $^1/_4$- or $^5/_{16}$-in. E6010 or E6011 mild steel electrode in the holder while feeding into the arc an alloyed, high-carbon or cast-iron filler rod. Several types of auxiliary filler rods are available, e.g., resultant deposits can be obtained to simulate high manganese, high-carbon and hard high-alloyed deposits. Two-Tone welding is two to three times faster (arc time) than ordinary welding, since 30% excess amperage is used on the live electrode to increase the burn-off rate, and the auxiliary or dead rod is fed in at the same rate per pound as the live electrode. Two-Tone welding is especially recommended for rebuilding large areas such as tractor rollers, shovel tracks, cement mill die rings, roll heads, etc.

The approximate composition of the deposit is determined by taking one-half the sum of each of the ingredients in the auxiliary filler rod and the electrode. Since E6010 or E6011 electrodes contain practically no carbon or alloys,[6] the weld deposit will contain approximately one-half the amount of all the alloys present in the filler rod.

Whether using Two-Tone welding or ordinary methods when hard surfacing large areas, it is wise to prevent too much heat from entering the parent metal, as this might cause breakage by rapid local expansion in one spot. This is especially true when welding on cast-iron manganese steel, or high-carbon heat-treated steel.

One cure is to skip weld, thus distributing the heat uniformly or, on smaller sections, to use a smaller electrode. When practical, preheating to 300° F. on cast-iron or high-carbon steel can be used as an added precaution, if the size and shape of the structure are such that cracking might occur due to too rapid expansion in one spot.

Thickness of Deposit Required

When rebuilding worn parts, it may be necessary to add several layers of metal to restore the original dimensions. If it has been decided that the final one or two layers should be a very hard wear-resisting metal, then a basic hard surfacing should be applied initially. The basic material could be medium-carbon steel electrodes, high-carbon steel electrodes, manganese electrodes or low-carbon low-alloy hard-surfacing electrodes. A hardness of 300 to 450 Brinell in the basic hard surfacing is permissible (Fig. 2).

Composition of Base Metal

Hard surfacing can be applied to practically all iron base metals and cannot be readily applied to the nonferrous groups. Most hard-surfacing applications are applied to mild steel, medium-carbon steel or manganese. When electric welding the dilution of weld metal with parent metal generally causes a lowering of the hardness. This is particularly true with some of the very heavily coated electrodes which have an arc similar to the E6020 electrodes, and hence penetrate deeply and increase dilution. This type of electrode is fast flowing, deposits a thin layer, and therefore the cure is to deposit two to three layers of weld metal.

However, when hard surfacing cast-iron and high-carbon steel, not only is the first layer hard, but since residual stresses in the weld metal tend to pull the whole hard-surfacing layer out of place, it is generally advisable to select a hard-surfacing weld metal which

[5] Two-Tone welding was developed by the author in 1941 and was used extensively during World War II for rapid rebuilding of hard-to-get tractor and shovel parts.

[6] Occasionally in Two-Tone welding, an inexpensive grade of hard surfacing is used in the holder (i.e., one containing 2–3% alloy and approximately 1% carbon—or even an electrode in the E10010 or E10020 class). In these instances the resultant amounts of alloy and carbon in the weld deposit are dependent on that present in the electrode as well as in the filler rod.

Fig. 6—New Hard-Surfaced Drag Links from Chain for Carrying Hot Cement Clinker

An electrode was chosen which resists both abrasion and high temperature, thus increasing wear and saving many man-hours for disassembly due to premature wear.

will check and hence relieve stresses in the weld metal. Almost all of the harder grades will check when electrically welded on large areas of any type base metal.

Work Hardening Encountered After Welding

When it is known that work hardening will take place after welding, an austenitic electrode can be used to advantage.[7] However, in many instances abrasion takes place before the surface is completely work hardened. Hence, this type of electrode should be chosen cautiously because in many instances one of the low-alloy inexpensive grades of hard surfacing which are hard all the way through as deposited are tough enough to stand the impact, and will wear better in case work hardening does not take place before abrasion rips the surface away.

Corosion and Erosion

If corrosion accompanies abrasion, choose a hard surfacing that will withstand both. To withstand corrosion, it is necessary to know what acids or alkalies are to be encountered, their concentration and the approximate temperatures attained, since hot, or concentrated, acids eat metal away much faster than cold or diluted mixtures. If sufficient data are not available, apply several layers of hard surfacing to a piece of stainless, Monel or other metal which is capable of withstanding conditions to be encountered, and immerse the sample a short time in the same acid. Test results can be obtained more quickly if necessary, by using higher temperatures. Manufacturers of hard surfacings frequently have corrosion data available.

[7] An austenitic hard-surfacing electrode is one which produces a comparatively soft deposit having a Rockwell of 20–30 C. However, it is tough and when subjected to battering or heavy blows, the surface will harden up to 35–45 Rockwell C, while core will remain soft.

To withstand erosion—e.g., on a water wheel, stainless steel has been found satisfactory.

Heat Present or Created (if Any)

In some instances the hard-surfaced part encounters high temperatures, for example, a drag link chain carrying hot cement clinkers (see Fig. 6) or pins used in tongs for lifting hot billets in a steel mill. This type of heat produces the same softening effect as the heat generated due to friction, for example, a hard-surfaced high-speed cutting tool becomes hot due to constant friction. Both require a hard surfacing which will maintain approximately 80% of its hardness at temperatures up to 1000 or 1500° F. To resist high temperatures, choose a hard surfacing that is not readily annealed by high temperatures. The hard-surfacing electrodes of this class generally contain either a high percentage of tungsten, or in some instances they may be composed largely of synthetic crystals which resist high temperatures. Hardness data at elevated temperatures can be obtained from the manufacturer.

Subsequent Heat Treating or Machining (if Necessary)

In tool steel welding it is often necessary to heat treat the die or tool after welding. In order that this can be accomplished properly, choose a tool steel electrode which will produce a deposit having the same heat-treating cycle as the parent metal. For example, if an oil-hardening die is to be welded, choose an oil-hardening electrode—i.e., one which will take the same heat treatment as the parent metal—and produce approximately the same hardness when welded or after heat treating. This does not necessarily imply that the analysis of the weld deposit should be identical to the analysis of the parent metal. Before welding, e.g., on an oil-hardening steel, preheat to approximately 300° F. which is 100° below the draw range of the parent metal. If desired, the die can be annealed and machined after welding and subsequently heat treated to obtain the original hardness—although frequently this is not necessary, since grinding to shape is often satisfactory. The same is true for air hardening, water hardening or high-speed tool steels, with the exception that the heat-treating cycles vary and the weld deposit should conform to the heat-treating cycle of the parent metal.

In general-purpose hard surfacing, sometimes it is necessary to machine the parts after hard surfacing, for example, after building up worn shafts, gears, etc. Generally these parts could be ground, but occasionally the necessary equipment for grinding is not available, or grinding is considered too expensive. In this instance, choose either a hard surfacing which is soft enough for machining as-welded, or one which can be annealed for machining and subsequently rehardened.[8]

Tool steel electrodes are usually a drawn type and are generally in the low-alloy classification. Electrodes for machining after welding without subsequent annealing are generally drawn electrodes producing weld deposits in the low-medium (0.30 to 0.40%) carbon class. However, ordinary grades of stainless steel or certain grades of aluminum bronze could be considered in this class also.

[8] Very few of the hard-surfacing electrodes other than tool steel or low-alloy electrodes can be readily annealed for machining.

Welded Pier Leg, Shear Leg and Trolley of a 15-Ton Ore Bridge*

By George F. Wolfe†

IN the construction of a 15-ton ore bridge for installation at the Bethlehem, Pa., plant of the Bethlehem Steel Co., electric arc welding was used for the first time on several major components of such a structure. Except for the main truss span and a few steel castings used in conjunction with weldments, all parts of the bridge are welded.

The contractor's war experience included the building of a large number of cranes of all-welded construction among which were 20 floating cranes of 100-ton capacity and two land installations of the gantry type with a total operating weight of 830 tons each. This experience, coupled with a desire to build a structure with low maintenance cost, focused attention at first on an all-welded bridge. Two conditions arose which indicated that riveting of part of the bridge was preferable.

1. In order to obtain economy of construction in a welded design for the truss structure, it appeared desirable to use top and bottom chords in multiple panel length as is customary in riveted construction, thus entailing the use of gusset plates and consequently fillet welding. Studies of test data available when this project became active did not encourage the designers too greatly as there seemed to be some doubt as to the effect of fillet welding on structural members subjected to alternate or pulsating stress conditions similar to those which are encountered in a bridge of this nature.

2. A very practical and tangible consideration was the fact that the customer desired to fabricate the truss structure in one of their own shops which was not equipped for welding. As a result of the technical and practical conditions involved it was decided to rivet the entire superstructure.

Several months later this judgment and decision was confirmed by additional information published in Report No. 4 of the Welding Research Council of the Engineering Foundation covering Fatigue Strength of Fillet, Plug and Slot Welding in Ordinary Bridge Steel. This report, published in the Research Section of the July 1945 issue of THE WELDING JOURNAL, in summarizing the results of some of the most recent fatigue tests, presents a tabulation of recommended dependable values in fatigue strength of main material under tensile stress when connected by fillet welds for 2,000,000 load cycles as follows:

Full reversal	5,400 psi.
Zero to tension	9,000 psi.
Tension to $^1/_2$ tension	13,500 psi.

It is to be noted that these values are considerably lower than those given in the 1941 edition of the A.W.S. Specifications for Welded Highway and Railway Bridges and that the stresses as given are recommended for only 2,000,000 load cycles. An ore bridge cannot be built under the A.W.S. Bridge Specifications as these specifications are intended for bridges which have stress changes either greatly smaller in range or less frequent in application.

The trolley of an ore bridge in the average steel plant will make from 200,000 to 300,000 trips per year. While all members will not pass through a complete stress range at each trip, it is obvious that even if the low stress values as given in Report No. 4 are applied some of the members would have a relatively short life if fillet welding were used. The alternate construction to fillet-welded gusset plate design would be butt welding with some riveting required for the attachment of cross framing to the main trusses, but so far no economical design is available to meet the demands of a competitive market.

A great amount of credit is due to the various agencies and individuals who are responsible for the restrictive data which have been made available covering fatigue stresses; but if further advance is to be made in welding material-handling bridges, we should not remain too long in what one could call a state of suspended animation. There is a definite need for further research on

* Scheduled for Twenty-Seventh Annual Meeting, A.W.S., Atlantic City, N. J., week of Nov. 17, 1946.

† Welding Consultant, Dravo Corp., Pittsburgh 25, Pa.

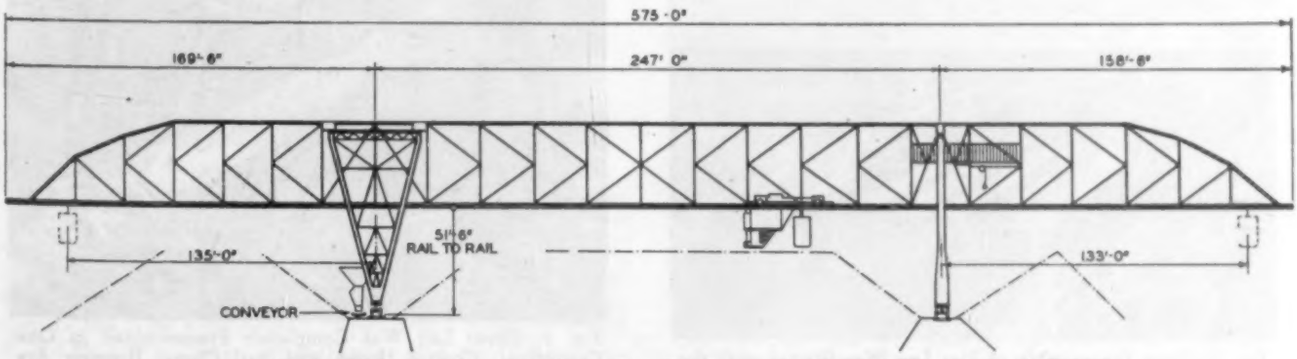


Fig. 1—General Elevation of 15-Ton Ore Bridge with Over-All Length of 575 Ft.

Fig. 2—The All-Welded Pier Leg Was Erected with a Minimum of Falsework as Shown

full size joints more like those to be used in actual practice. Such a program of research will be expensive and will necessitate a close cooperation of manufacturers and users in order to justify extensive research on large scale sections.

The Bethlehem Ore Bridge, as shown in Fig. 1, is of the skew type with a main span of 247 ft. and cantilever spans of 158 ft. 6 in. and 169 ft. 6 in. The total weight of the bridge in operating condition without ore in the bucket or in the conveyor loading bin is approximately 1250 tons. This load is carried on the two legs, each of which has a total of 32 wheels fully equalized for the carrying of this weight on 4 ft. $8^1/_2$ in. gage tracks. All wheels are driven with a single 65-hp. motor driving 16 single-flanged rolled steel 27-in. diameter wheels at each end of each sill through a worm gear drive. Two automatic rail clamps are provided at the center of each sill to hold the bridge against a wind pressure of 45 lb. per square foot on the entire structure. The bridge travel speed is 100 ft. per minute against a 10-lb. wind and provision is made so that each leg of the bridge may advance in either direction beyond the other until a 5° skew is reached.

Fig. 3—Shop Preassembly of Pier Leg Was Started with the Box Girder Unit Shown in Background

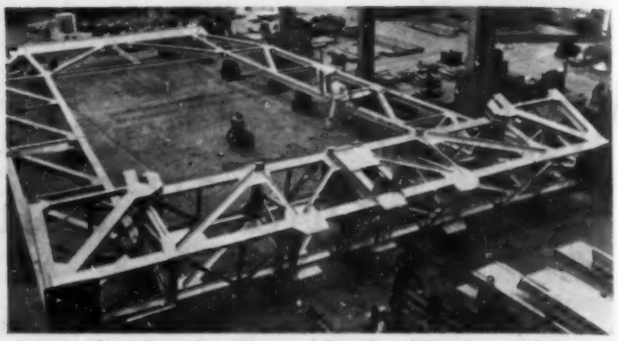


Fig. 4—One Complete Plane of Pier Leg Was Assembled with Sill; After Removal of First Plane, the Sill Was Turned Over and Second Plane Was Fitted

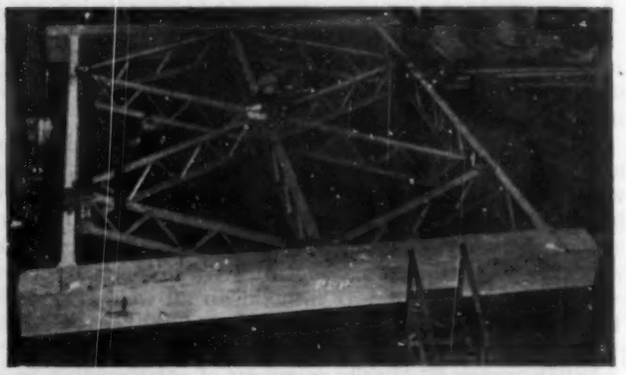


Fig. 5—Top Box Girders with Horizontal Bracing System Made Up the Final Preassembly of the Pier Leg

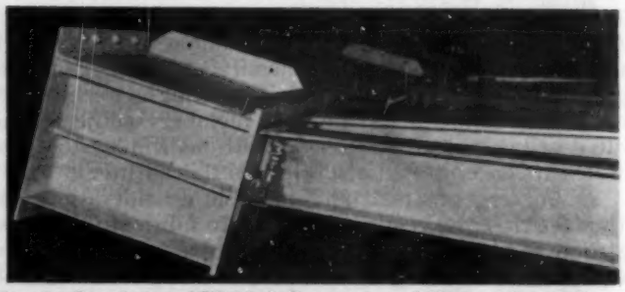


Fig. 6—Simplicity of Welded Connection of Sloping Leg to Box Girder Is in Sharp Contrast to Usual Rivet Connection Where Legs Enter the Girder

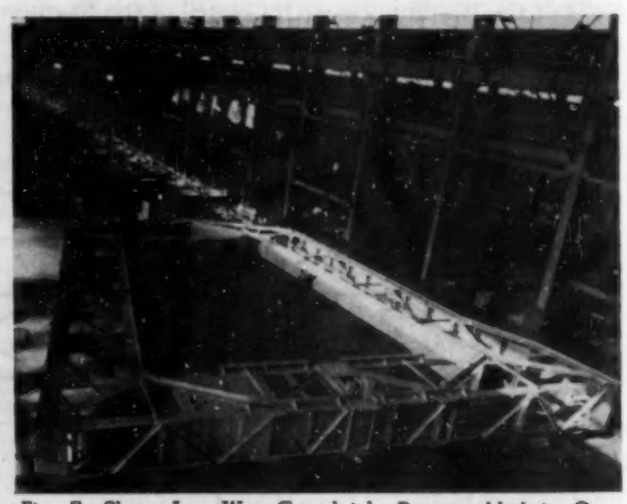


Fig. 7—Shear Leg Was Completely Preassembled in One Operation; Control House and Rail Clamp Housing Are Integral Parts of the Sill Member

The all-welded trolley, which weighs approximately 120 tons with loaded bucket, is supported on four 33-in. diameter spring-mounted single-flanged rolled steel wheels. Two 75-hp. motors drive the axles through herringbone gear reductions. The trolley travel speed is 900 ft. per minute with hydraulic buffers provided at each end of the bridge runway. These buffers completely decelerate the loaded trolley from full speed in a travel length of 6 ft. in case of an emergency. Limit switches

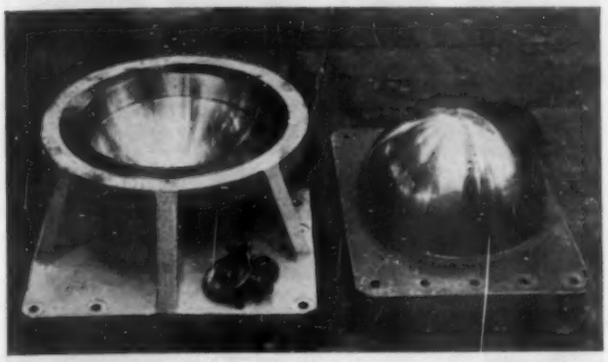


Fig. 8—Polished Steel Hemisphere Resting in Bronze Bushed Socket Provides Sole Support for the Superstructure at the Shear Leg

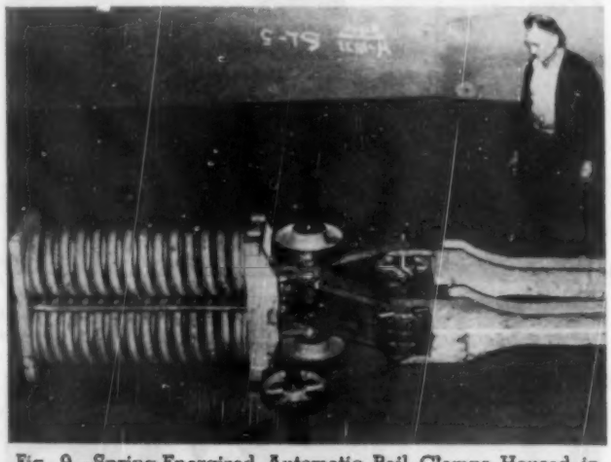


Fig. 9—Spring-Energized Automatic Rail Clamps Housed in All-Welded Structure of Sills Provide Safety Against 45-Lb. Wind on Entire Structure

Fig. 10—Shop Preassembly of Truck Equalizer System Shows Clean-Cut Construction Made Possible by Welding

are provided for normal operation to stop the trolley before it reaches the buffers. Two series-wound motors of 275 hp. each, working through worm reduction units, operate the four rope drums to provide a hoisting speed of 230 ft. per minute. Resistances and controlling apparatus are mounted in an all-welded housing suspended

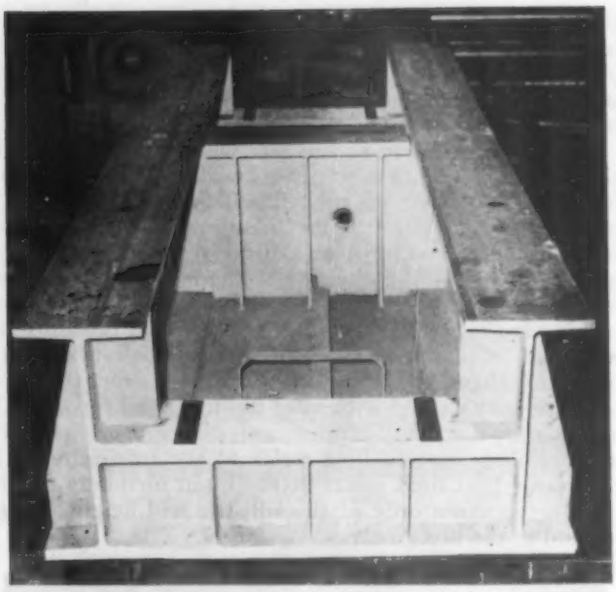


Fig. 11—Heavy Beams, Slabs and Plates Properly Welded Produced a Main Equalizer of Great Strength and Simplicity

from the rear end of the trolley with the operator's cab located beneath this control house.

In order to insure proper tracking of the trolley, the trolley rails are inclined toward the center of the track by furnishing a beveled plate under the rails to provide an inclination of 1 to 40 to match the taper of the tread of the single-flanged rolled steel wheels. The trolley rails, consisting of AREA 131-lb. section, are arc welded at the butt joints and are held to the track girders by means of clips having two bolts each. These clips are bolted to the trolley beams and permit the rail to slide longitudinally when temperature changes occur. Rail butts were prepared for arc welding by preheating to 400° F. before burning and grinding to furnish a double V with total angle of 40° on the rail head and web opening from the sides and a single V of 40° on the base with temporary copper backing strip provided beneath the base while welding.

Pier Leg

The pier leg as shown in Fig. 2 consists of a double V-shaped structure with a trussed sill and carrying two box girders for the sliding support of the superstructure. Since this is a skew bridge, there are four points of support where the trusses of the span rest on the pier leg with a center pin provided at the center of rotation. In order to insure a smooth skewing motion, it is essen-

Fig. 12—Cast Steel Was Used for the Third Set of Equalizers in Order to Provide Housings for the Worm Drive and Transverse Shaft Bearings

tial that all four skew plates on the pier leg are in a true plane. In the consideration of welding for such a complex structure, it was decided that a complete shop assembly of both legs of the bridge should be made to insure proper fit and to avoid delays in final erection.

The shop assembly of the pier leg was carried out in three steps. The first step consisted in assembling one full plane of the V with the sill, which had been entirely preassembled. After the first plane was checked, it was removed, the sill member was turned over and the second plane was placed and checked. The final step consisted in assembling the two box girders with all horizontal bracing in the top of the leg. Except for the box girders, which are of plate construction, this leg consists entirely of beams, channels and angles. All main strength members are butt welded with fillet welding used for secondary members only. Shipping units were made as large as possible to reduce field welds to the minimum with the result that field joints in the main members of the pier leg occurred only at the sill, the mid-height of the leg and at the box girder.

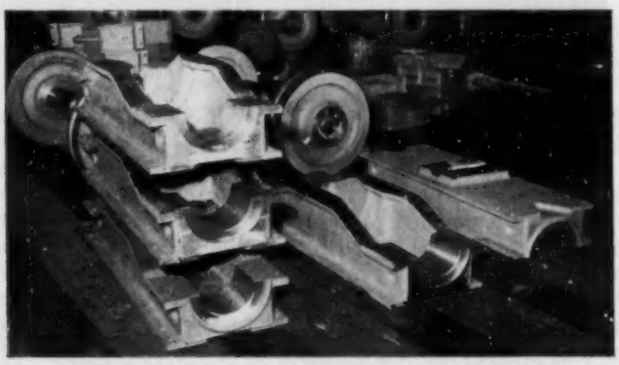


Fig. 13—The Fourth Set of Equalizers of Welded Plate Construction Provides Compensation for Possible Difference in Elevation of the Two Rails of the Bridge Travel Track

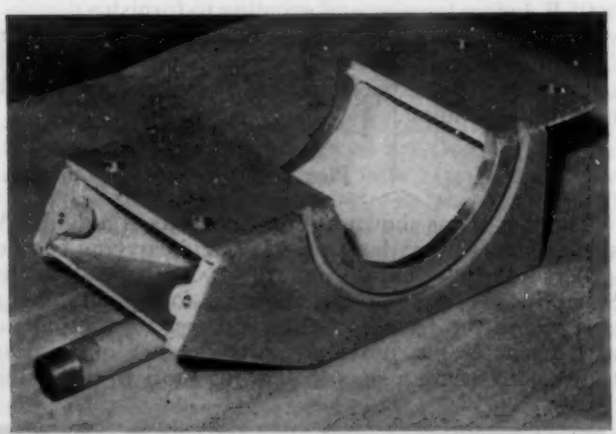


Fig. 14—The Oil Reservoir Used with the Axle Bearing Was One of the Smallest Welded Units in the Entire Structure

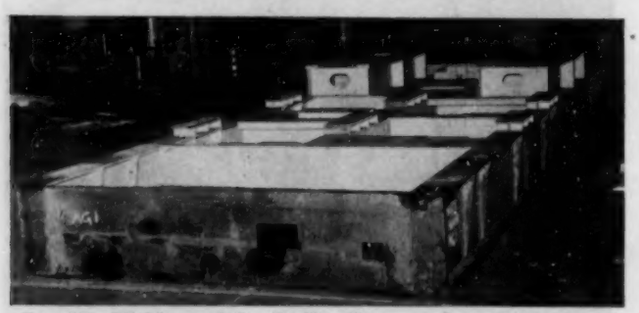


Fig. 15—Welding of the Trolley Framework and the Use of Some Low-Alloy Steel Permitted Considerable Saving in Weight Without Sacrificing Strength

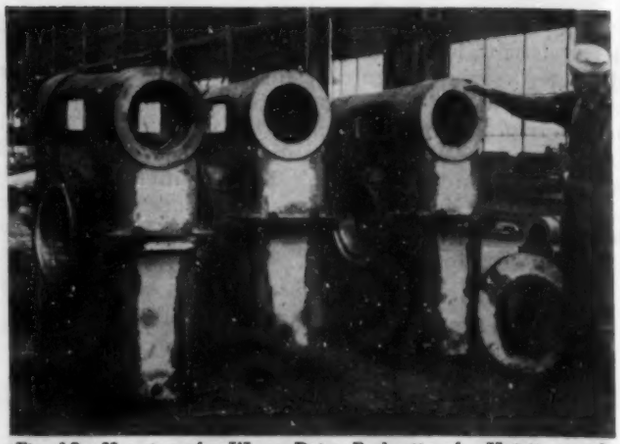


Fig. 16—Housings for Worm Drive Reduction for Hoisting and Closing Lines of Welded Plate Construction Incorporated Cast Steel Rings for Worm Bearing Supports

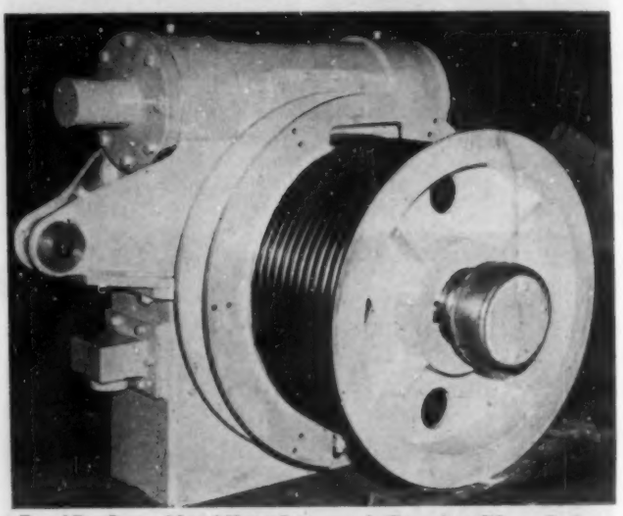


Fig. 17—Assembly of Hoist Drum with Complete Worm Reduction Unit; Use of Four Drums Permits Direct Lead to Hoover-Mason Type Bucket

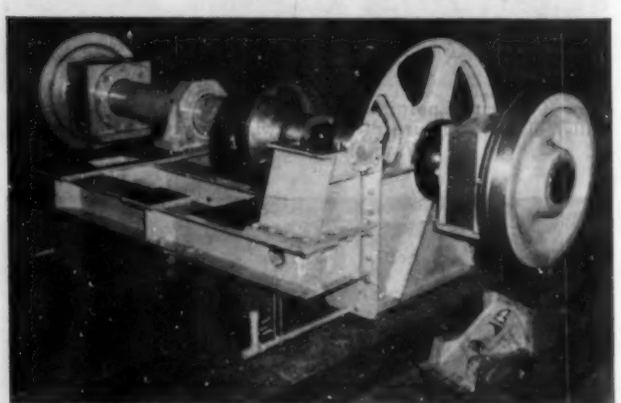


Fig. 18—Trolley Drive Motor Is Mounted on Welded Platform Arranged to Pivot About Trolley Axle; This Construction Keeps Motor Pinion in Proper Mesh with Gear Despite Vertical Movement of Spring Mounted Trolley Frame

The preparation for the butt joints for positioned shop welds consisted of standard 60° angle opening from one side. For horizontal field butts the lower section was cut square with 45° preparation on the upper member only. Welding of this complex leg resulted in great simplification of detail which was particularly beneficial in the attachment of the top box girders. In riveted construction it is customary to carry the leg members into the girders which, due to the double angularity of the legs, results in a most difficult and inaccessible connec-

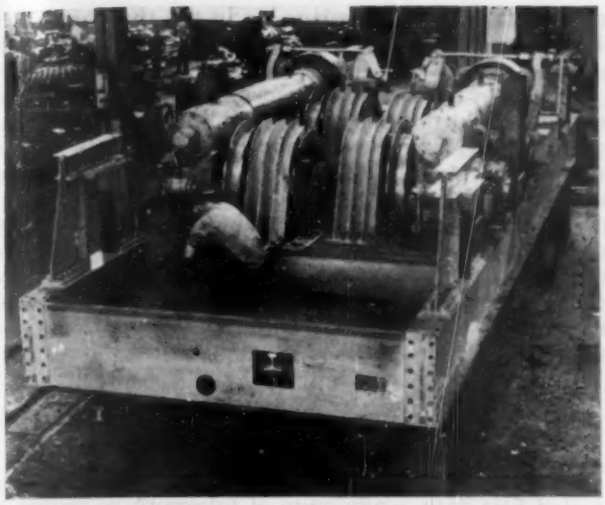


Fig. 19—Trolley Was Shipped Completely Assembled Except for Axle Assemblies Shown in Fig. 18

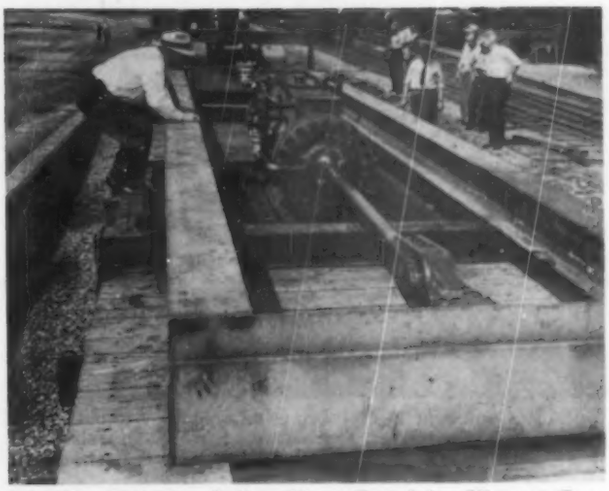


Fig. 21—Hydraulic Buffers Were Tested by Allowing Free Running Loaded Flat Car to Strike Buffers at Speeds Up to 1000 Ft. per Minute

tion. In the case of the welded joint all internal diaphragms were made vertical in the box girders and the welding of these girders was completed in the shop. The field connection of the box girders to the main leg members consisted merely in making an end weld of the sloping members to the underside of the heavy cover plate of the box girder.

Shear Leg

The shear leg was likewise completely shop assembled as shown in Fig. 7. This leg is of somewhat simpler construction than the pier leg and comes to a point at the top to provide a seat for the ball and socket joint as shown in Fig. 8. As the bridge skews, the shear leg leans toward the center span thus requiring the ball and socket type of support for the superstructure while the pier leg provides stability against overturning.

The sill construction, consisting of a deep double-trussed member, is similar for both legs with supporting structures built in at the center of each sill to provide for the installation of the automatic self-aligning rail clamps shown in Fig. 9. The control house for the shear leg is built into the sill as an integral part of the structure while the one for the pier leg is located in the spreading leg just above the sill. In both cases the construction of these houses was greatly simplified by welding.

Each end of each sill is carried on 16 wheels which must be equally loaded. This equalization of load is obtained by the system of equalizers shown in Fig. 10. The main equalizer, shown inverted in Fig. 11, consists of two 36-in. beams with a top cover plate. A center diaphragm is welded in to take the concentrated load from the end of the sill while heavy end diaphragms are provided for distribution of this load to the secondary equalizers. The secondary equalizers, consisting of two 21-in. beams with top and bottom cover plates, distribute the load to a third set of equalizers which are of cast steel construction and also serve as housings for the worm drive mechanism. These cast equalizers, as shown in Fig. 12, distribute the load to the final equalizer trucks which make provision for any discrepancies in the elevation of the two rails in the transverse direction. The component parts of these final equalizers are shown in Figs. 13 and 14 and show to what extent welding was carried in the truck design.

The only difficulty encountered in the building of these trucks was found in the cast steel equalizers. The bearing caps for the worm units had an internal rib which caused shrinkage cracks starting at the end of the rib and

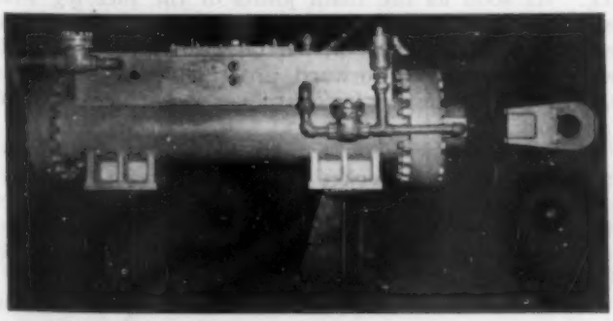


Fig. 20—Two All-Welded Hydraulic Buffers Were Provided at Each End of the Runway to Take the Impact of the 120-Ton Trolley at Full Speed

Fig. 22—Erection of Superstructure Started at Pier Leg as Soon as Main Joints in Leg Were Welded

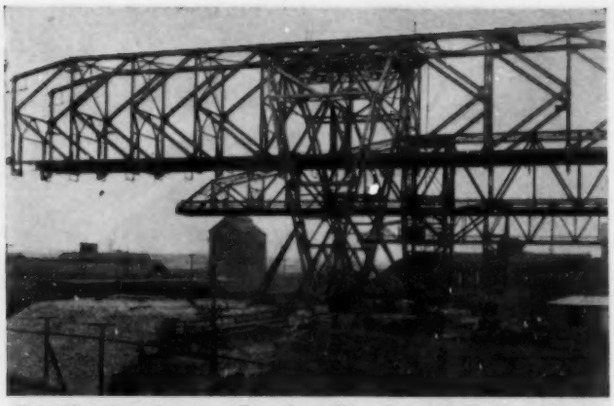


Fig. 23—Cantilever at Pier Leg Was Erected Without Falsework; Main Span Was Erected with Two Steel Falsework Bents Which Were Moved Progressively Forward

extending into that portion of the cap which was bored out to receive the supporting ring of the bearing race of the worm shaft and were not visible until machining neared completion. Since the cracking was found to exist in all of the castings, there seemed to be no solution to the problem by securing additional castings with a considerable delay involved so the cracks were chipped out and welded. By using $^1/_{16}$-in. electrodes, keeping a careful check of distortion during this repair and peening when necessary, it was possible to salvage all of the castings including some which had been finish bored where it was necessary to maintain extremely close tolerances.

Trolley

The main framework of the trolley, as shown in Fig. 15, consists of a weldment 10 ft. 9 in. wide by 33 ft. 5 in. long with a net weight of approximately 17,000 lb. For the 27-in. beams forming the main longitudinal strength members, the transverse end channels of bent plate and floor plates not shown in this illustration, Mayari-R steel was used to reduce the dead weight. In order to avoid stress raisers in the tension flanges of the main side beams, all stiffeners were terminated before meeting the bottom flange and the webs of transverse beams were coped back so that there is no welding across these flanges of the main strength members.

The four rope drums are a combination of a cast steel hub with ribs, shell and flanges of welded plate construction. An extra length of drum with a separating flange is used to provide storage space for sufficient additional wire rope to permit several cutoffs in that portion at the bucket where wear is greatest. The more complex worm gear housing units for the trolley are also welded entirely of rolled steel except for the use of two cast steel bearing barrels in the upper portion of the housing. A designer should not hesitate to use steel castings in building up weldments where, as in the two cases cited above, structural and economical conditions justify such usage.

Fig. 24—Shear Leg Trucks and Rail Clamps in Position on Track; Note Main Span Approaching from the Left

The trolley control house suspended beneath the trolley was shop welded into large assemblies while the operator's cab was shipped as a complete unit with all control equipment and electrical conduits installed. Additional saving of weight was obtained by using Mayari-R steel for the floor plates and most of the siding in the trolley control house and operator's cab. In the case of a bridge with long cantilever spans, the saving of weight in the trolley is doubly important as it reduces stress fluctuations in the truss members and also reduces the bridge travel wheel loads.

Field Erection

In accordance with standard practice, the pier leg was erected first with a minimum of falsework as shown in Fig. 2. All joints were brought into the same relative position they had in the shop assembly and when the top girders were placed all four corners were in a uniform plane and no vertical adjustment was required. Welding was done in a simple sequence working from the bottom upward and keeping welders balanced around the leg. As soon as the main joints of the pier leg were welded, the erection of the superstructure was started with the center span carried on two falsework bents which were moved forward progressively toward the shear leg while the pier leg cantilever was erected without falsework.

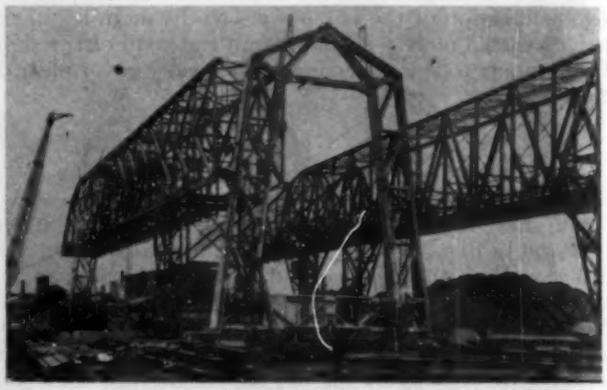


Fig. 25—Shear Leg Fully Erected Shows Smooth Surfaces and Clean Lines Obtained by Welding

Fig. 26—Superstructure in Place with Temporary Beams on Top Chord Just Beyond Shear Leg for Hoisting Trolley

The shear leg was erected and welded without adjustment as the ball and socket type of support for the superstructure does not require any special refinement in either height or position. The main span was then continued to the shear leg and again the cantilever at this leg was erected without falsework.

At the time of the preparation of this paper in the early part of August, the structure was fully erected as shown in Fig. 26 with riveting only partially completed. It is hoped that final pictures of the fully assembled trol-

ley and the finished structure will be available for presentation at the annual meeting.

After the superstructure is riveted, the trolley track girders will be aligned and riveted. The butt joints of the rails will then be welded following a welding procedure which has proved successful in the customer's plant on numerous crane runways and railroad crossovers for several years. Following a preheat of about 400° F. an E-6012 electrode will be used for the entire butt with the exception of the top $^1/_4$ in. in depth of the rail head which will be completed with an E-10010 electrode. This procedure is rather different from that used on rail replacements on several coal bridges in the Great Lakes district in the last couple of years where an E-10010 electrode has been used for the entire butt weld. In the case of the coal bridges the rails were welded to the trolley girders whereas the rails in the bridge under discussions are free to move lengthwise with change of temperature.

During the last two or three months there has been a considerable demand for new ore and coal handling bridges in various steel plants. Most of the mill people wish to secure bridges as fully welded as possible as they appreciate the lesser maintenance of the welded structure. Many bridges are located near sinter plants where the always prevalent abrasive and corrosive sinter dust filters into every crevice causing early obsolescence of a very expensive piece of machinery.

Under such conditions the desire for all-welded material-handling bridges will become a demand and welding designs and processes will have to keep pace with such demands.

Design for Resistance Welding*

By I. A. Crawford†

THE metal industries have accepted welding as a means of increasing production at a lower cost than other accepted methods of metal joinings. The automobile industries have proved the merits of resistance welding on their production lines, however, manufacturers of automobiles are constantly spending thousands of dollars on new designs and the greater part of this expenditure will be allocated to the investigation of resistance welding. Since resistance welding has increased production in the automobile plants where competition is keen, we can assume that resistance welding can increase production and reduce costs in other industries.

The efficiency of a resistance welding program depends upon a well-planned organization capable of directing the engineering staff in the design for resistance welding. In smaller plants where the expenditure of such an amount would not be justified it is recommended that a thorough study of welding methods and designs be made. This can be accomplished by referring to the R.W.M.A. Manual, the A.W.S. *Handbook* and other publications.

If resistance welding is to be successfully utilized it is necessary that certain factors be considered prior to giving the engineer a design. These factors can be summarized as follows:

1. Application.
2. Activity.
3. Material.
4. Type of joint required.
5. Resistance welding processes to be used.
6. Welding equipment and power requirements.
7. Tool and fixtures.
8. Welding information.

The application for which the assembly will be used determines the suitability of the design. Operating requirements such as shear, tension, compression, impact and torque loads must be considered. Vibration, intermittent and constant loads are other factors which determine the quality of the welded product.

The production activity determines the practicability of converting to resistance welding. Where continuous production can be assured the initial investment in resistance welding equipment can be justified. However where the activity is limited job welding shops equipped with resistance welding equipment can be utilized and a cost reduction can be realized. The activity also controls the tooling costs. Naturally where there is a high production involved, the cost of tooling, such as dies and fixtures, can be amortized and will show a very small per unit cost.

The materials used in the assembly will control the type of resistance welding equipment required and in turn will determine the power requirements. Certain metals have not been successfully resistance welded, therefore it is necessary to select the type of metal that is weldable. The thickness of the metal, the shape and the size of the assembly must be considered when designing for resistance welding. All joints to be welded must be accessible, and where possible the two pieces of metal being welded must be of uniform thickness. In designing the assembly, keep in mind the importance of having uniform metal thickness so that time can be saved, due to the fact that the operator will not have to continually change the heat controls for the proper weld time.

The type of joint must be one where sufficient welding space is allowed. Factors such as flange width, size and location of spots must be considered. It is not always possible to design the assembly with ideal joints, therefore, it is necessary to utilize other welding methods in conjunction with resistance welding. The joint must be so designed that the welding can be performed without undue handling of the assembly and/or the welding equipment being used.

The type of joint governs the type of resistance welding equipment to be used, that is, single spot, projection, flash or butt welding, multispot or the gun type of equipment. If properly designed with the thought in mind of using any of these methods, production can be increased at a lower cost. Again the type of equipment depends

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upon the size of the parts being welded. If the assembly is too large or of an irregular shape, subassemblies can be resistance welded and the final assembly arc welded.

The metal industries have proved the merits of proper tools and fixtures on production lines, and to successfully carry out a resistance welding program it is necessary at the time of designing the assembly for welding, to consider fixtures, tools and handling equipment. On small parts simple gadget-type fixtures can be readily made from aluminum, or of steel where parts are insulated. It is also possible to so construct the welding dies that they will serve as holding fixture while acting as the welding electrode. Where the parts are large and can be handled on a flat surface it is suggested that a ball top table be designed around the welding equipment. Many users of resistance welding equipment use a swing type fixture; however, it is believed that this equipment is awkward to use and does not offer the advantages of a ball top table.

An important phase of resistance welding is commonly used in the plants of electrical manufacturers; however, it is not used very extensively outside of this industry. The method referred to is resistance brazing of various alloys. Resistance brazing is accomplished by using carbon inserts or carbon blocks as electrodes instead of the conventional copper alloys. A brazing agent such as easy flow, sil-fos and phos-copper or a commonly used soft solder is used as a medium to join the alloys.

It is of prime importance that each resistance welding job be properly recorded for future reference not only in checking quality but ascertaining machine settings on future welded assemblies. A job record card can be made giving all pertinent information such as material specifications, condition of material surfaces, type of equipment, tap settings, pressures, weld time, weld appearances, and so forth.

The latest type of equipment, the most complicated controls, expensive tooling, the best-designed fixtures and the most complete welding information are not in themselves sufficient to guarantee a quality product if the design of the product has not been developed and proved for resistance welding.

As a manufacturing engineer and research development engineer I have had occasion to confer with and advise on numerous resistance welding projects; the most outstanding case, one where five new welders were just installed. The dies used were of the progressive type and the parts being welded did not fit any of the dies or fixtures designed by the manufacturer of the welding equipment. In fact the resistance welding supervisor had welded one assembly and was unable to release the welded unit due to the construction of the fixtures. After rebuilding the fixture I was determining the proper machine settings, and used the term 15 cycles. The resistance welding supervisor asked the question, "What is meant by cycles?" Knowing that he had spent eight years in resistance welding, I was surprised. However after a brief discussion of the fundamentals this supervisor proceeded to work out a program whereby production was increased and cost lowered.

Another case was that of a manufacturer of gears used on chain drives. To construct this gear, which was approximately 6 in. in diameter, it was necessary to obtain a 6-in. round bar and machine this bar so that the gear plate would be of $^1/_4$-in. thickness and the gear hub 2 in. long. This method was compared with the possibilities of resistance welding and the part was changed so that the gear plate could be stamped from flat material and the gear hub made from a 2-in. round bar, the parts being then projection welded, forming a complete gear at the fraction of cost of the original.

Another example where resistance welding was not considered was in the assembly of certain parts simply because the assembly had always been joined by gas brazing. This assembly was the ring and saddle part of the guide which is assembled to a fish rod. After analyzing the assembly it was found that it could be resistance brazed at the fraction of cost of gas brazing. It was originally estimated that one operator and one assembler could torch braze approximately 150 of these assemblies per hour. However, production was increased to 500 per hour by the use of resistance brazing. The cost of labor being the same as that required to produce 150 assemblies.

Another example of the use of resistance welding assisted the manufacturer of steel products to remain in business in spite of the steel shortage. This manufacturer was making an assembly where it was necessary to use T iron. Being unable to secure this type of material he was forced to find a substitute and it was suggested that by using two pieces of $^1/_8$ by 1" scrap iron he could resistance weld this material together in the form of a T. This was accomplished by forming an embossment or a projection on one part and welding same to the other part. Another example in the conservation of steel was an automobile manufacturer who was making an auto trim assembly and suddenly realized that he could not secure sufficient metal to complete the order. By redesigning the part and by use of projections the manufacturer was able to save 5 in. of material on each assembly.

The above examples are but a few of the many products redesigned for resistance welding to increase production and effect a cost reduction as well as conservation of steel. The trade magazines carry ads and stories covering new developments in the resistance welding field and in every case it is possible to see where the design for resistance welding played a major part rather than the design of the resistance welding equipment.

Some Problems of Welding Design and Fabrication of Steel Floating Drydocks*

By A. Amirikian†

A LARGE number of floating drydocks were built during the war by the Navy's Bureau of Yards and Docks, for rendering repair service to the fleet. In normal times, with only a limited number of ships in operation, practically all such repair and overhaul work is accomplished in graving docks located at various Navy yards. Obviously, these land docks could not provide the required service for a tremendously expanded wartime Navy. To meet the emergency, this large group of floating drydocks not only furnished the required number of additional repair facilities but, still more important, provided mobility to the facilities by following the fleet to render service at distant stations and advanced bases.

A proper classification of floating drydocks in accordance with conventional terminology of ships and other water craft is somewhat difficult. Lacking self-propulsion, and in body contour unlike any other craft, floating drydocks may well be classified in a separate category of structures. Since set rules and regulations pertinent to ships and vessels were not considered as applicable to these structures, it was necessary to develop a new design technique and construction procedure.

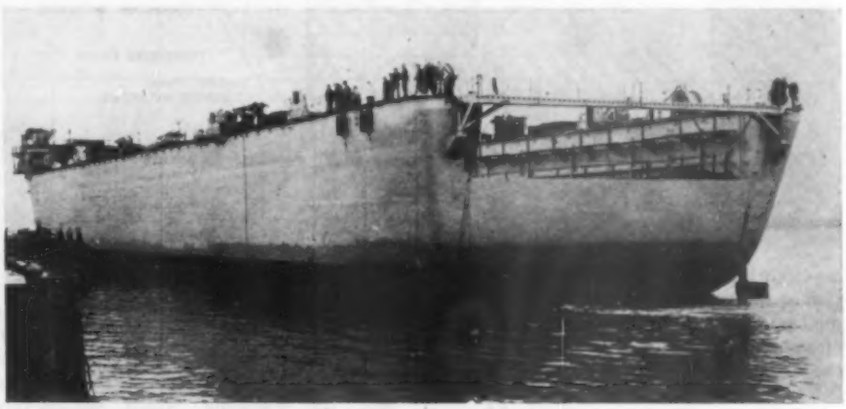

Fig. 2—Floating Drydock with Ship-Shaped Bow and Stern Gate

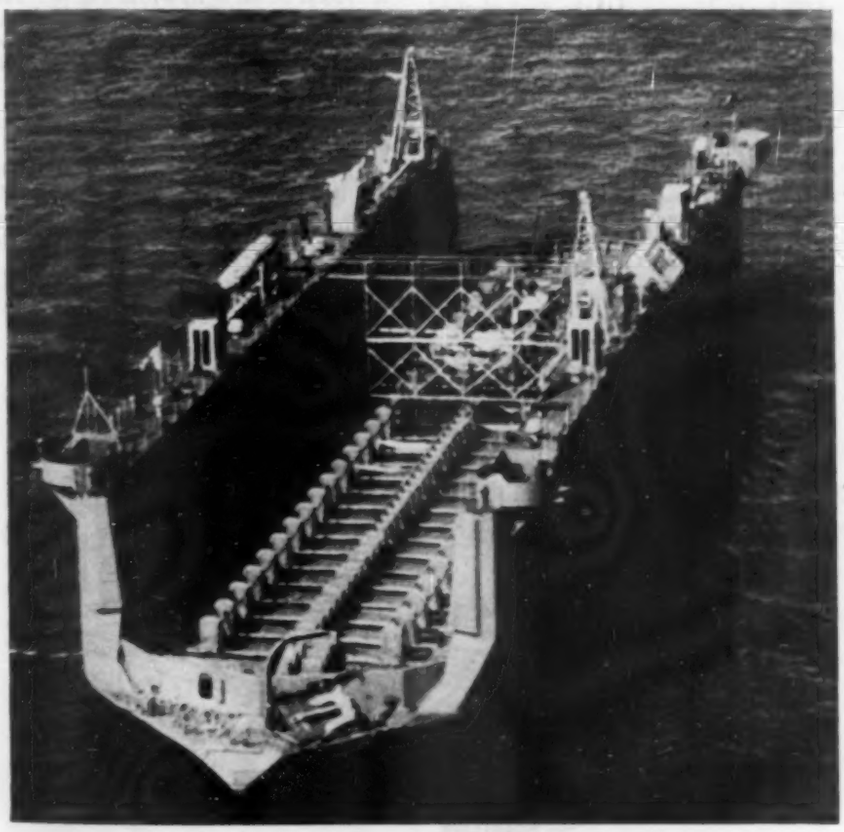

Fig. 1—Floating Drydock with Open Ends

Essentially a floating drydock is a channel-shaped floating basin. In most types the ends of the basin are open (Fig. 1); in some types, however, the channel is closed at one end by a ship-shaped bow and at the other end by a gate (Fig. 2).

With a few exceptions, all floating drydocks were built of steel and utilized all-welded framing. When the huge project got under way in the spring of 1940, the first unit of the program represented the largest all-welded floating structure, both dimensionally as well as in weight, built up to that time. It was also the first time that welding was used to any extent in the construction of a floating drydock.

The design criteria of a floating dock are clearly defined, since they are predicated on a simple mission, which is to lift ships out of water and provide the required repairs in the dry. Briefly, these criteria consist of requirements of capacity, strength, stability and equipment.

The requirements of capacity and stability are provided for by the dimensional characteristics of the dock. These characteristics, which include the over-all dimensions and a cross-sectional outline are, in turn, governed by the weight and dimensions of the ships that are to be lifted or serviced.

The strength requirement, most important factor in design, is governed by the framing of the dock. For a satisfactory arrangement, the proposed framing should not only provide adequate

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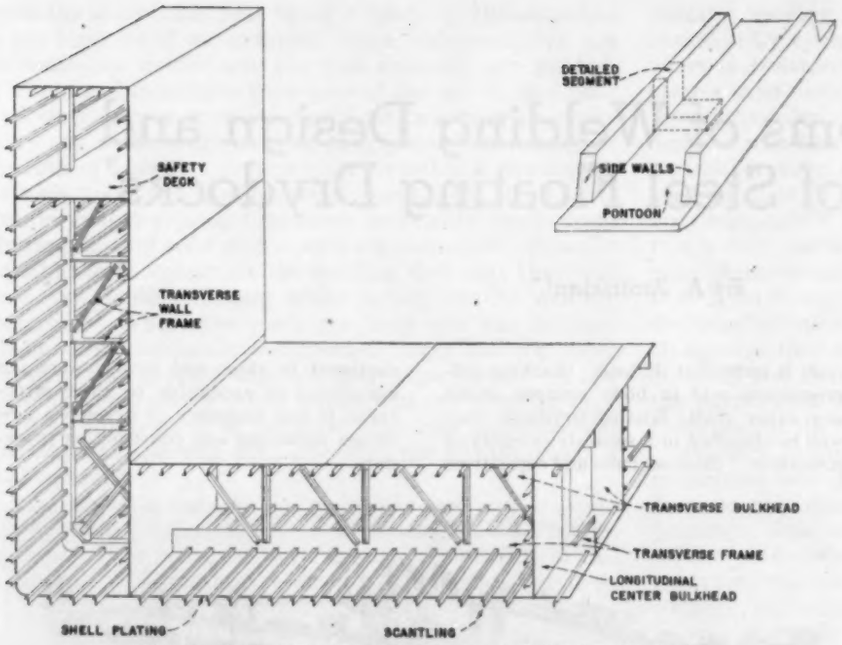


Fig. 3—Typical Framing Arrangement of Floating Drydock

strength but assure economy of construction as well. To this end, as a measure of relative merit, the weight of the framing is often expressed in terms of the capacity of the dock. For a given set of criteria of design, the most meritorious design is one which involves the least amount of framing weight per unit of lifting capacity, that is, the minimum ratio of the dead weight of the dock to the weight of the largest ship to be lifted.

Arrangement of Framing

The framing problem of a floating dock is more in the domain of the structural engineer than the naval architect. This is due to the fact that the shaping or streamlining is of little importance, since, as stated above, the cross-sectional outline of the dock channel is determined by the lifting and clearance requirements of the ships to be serviced. Once the dimensional characteristics of the dock have been thus determined, the design work then resolves into a straightforward structural analysis.

The dock channel is formed by two sidewalls and a floor pontoon. As in the case of all floating craft, the framing is of cellular type, that is, the sidewalls and the floor pontoon are subdivided into a number of interior compartments. The cells or compartments are composed of shell plating and a system of interior stiffeners, consisting of the scantling or stringers, transverse frames and longitudinal and transverse bulkheads. A typical framing arrangement is shown in Fig. 3.

The interior compartmentation of the dock is governed primarily by the chosen pumping arrangement. In adopting a layout, however, considerations are also given for the requirements of stability and freeboard in submergence.

Properties of Framing

The stresses in a floating dock, whether at sea or when docking a ship, are of both local and over-all character. Local resistance is provided by the shell plating and the scantling which successively take the local hydrostatic or buoyant forces and transmit them to the frames. The over-all strength of the dock is provided by the frames and the dock section as a whole. In selecting the components of framing, the various members are so chosen that they not only meet with the design requirements of pertinent local and over-all stress combinations but are, at the same time, adaptable for simple and efficient welded jointing. These basic requirements, as applied to each component of framing, may be summarized as follows:

Plating

The stress pattern of shell plating is definitely biaxial. In a typical panel bound longitudinally by two stringers and transversely by two frames, important stresses may occur in either direction, since the same plate provides common flange material for both the stringers and the frames. This condition of stress requires homogeneity of plating which is obtained by specifying tensile tests of plate specimens both longitudinally (parallel to direction of rolling) as well as transversely. Additional requirements include weldability and ductility. These requirements are generally met by limiting carbon to a maximum of 0.30% and by specifying a minimum ductility of 25%. Where the plating is to be shaped, such as in the bilge and at the bow and stern, it is specified that the plating be of flanging quality in order to obviate possible cracking during cold bending or subsequent welding in assembling.

Scantling

Like the shell plating the nature of stress in scantling is of local character, being derived from stringer action in supporting the plating and transmitting the load to the frames. In addition, the scantling acts as a stiffener to the flange plating of the frames and provides a part of the cross-sectional area of the dock in longitudinal bending. In order to assure economy from the standpoint of local flexure, which constitutes the most important source of stress, the scantling is designed for full continuity. Further savings in weight are accomplished by the use of serrated sections cut from channels. A typical detail is shown in Fig. 4. The run of the scantling is in the longitudinal direction of the dock and the spacing may vary from 20 to 30 in. in accordance with location and loading.

Frames

The transverse frames in the sidewalls and in the floor pontoon are of open-web truss type. In some cases of pontoon framing, however, solid-web frames are

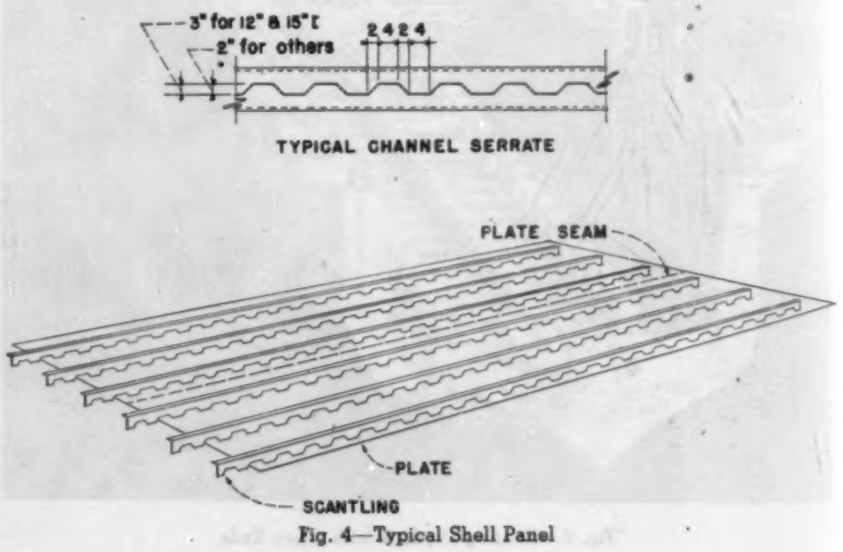
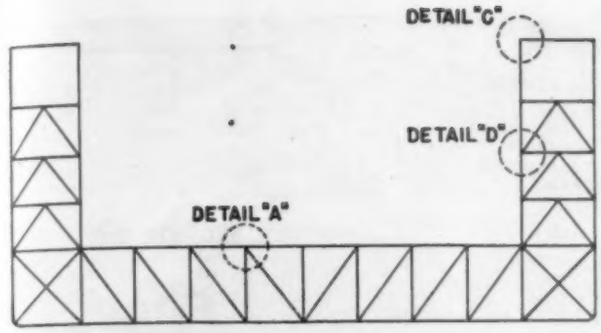


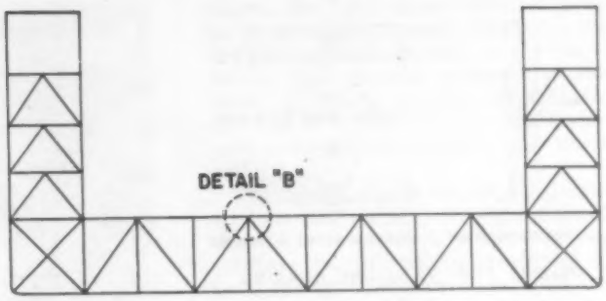
Fig. 4—Typical Shell Panel



TYPICAL · TRANSVERSE · FRAME

Type I

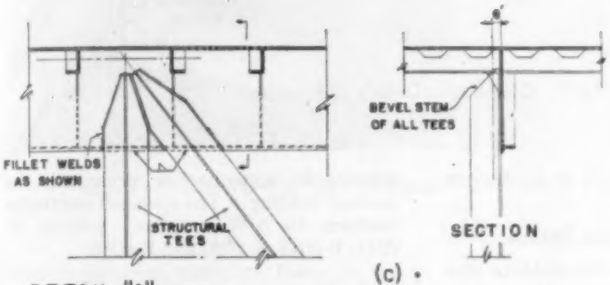
(a)



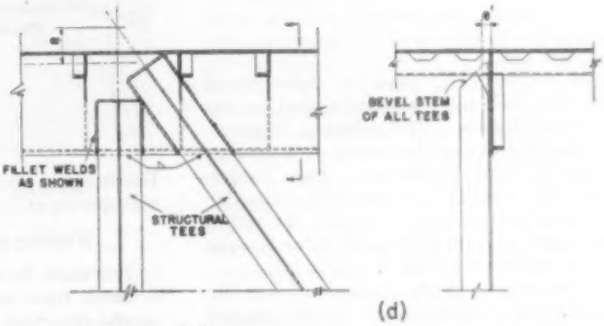
TYPICAL · TRANSVERSE · FRAME

Type II

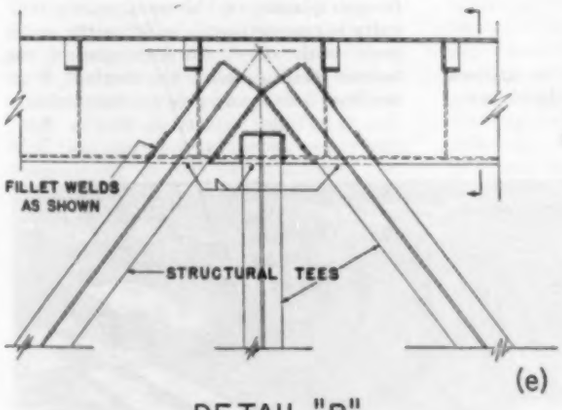
(b)



DETAIL "A" METHOD 1



DETAIL "A" METHOD 2 SECTION



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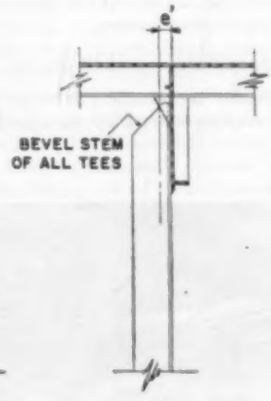
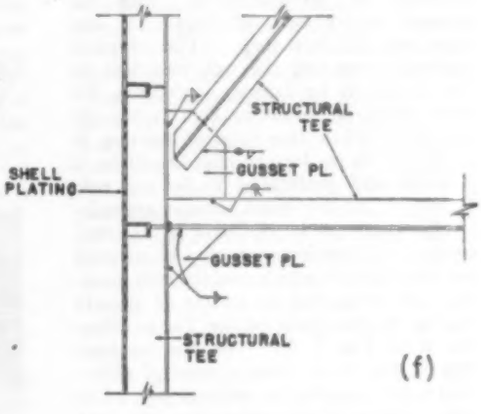


SECTION



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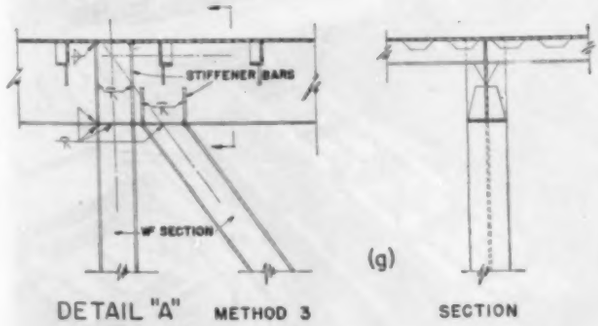
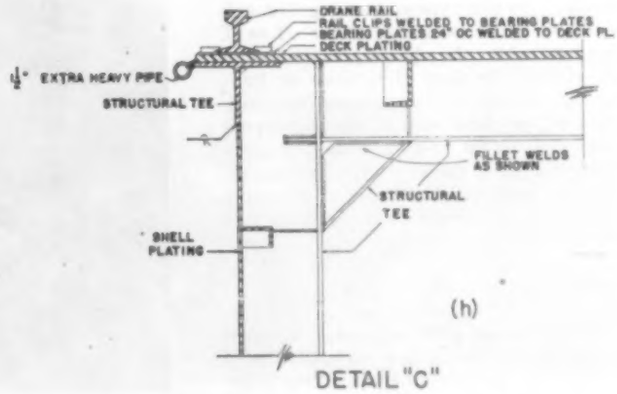
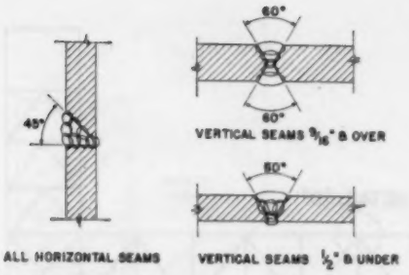


DETAIL "A" METHOD 3 SECTION



DETAIL "C"

Fig. 5—Typical Joint Details of Transverse Frames



WELDING FOR VERTICAL PLATING

WELDING FOR HORIZONTAL PLATING

Fig. 6—Typical Weld Details of Shell Plating Seams

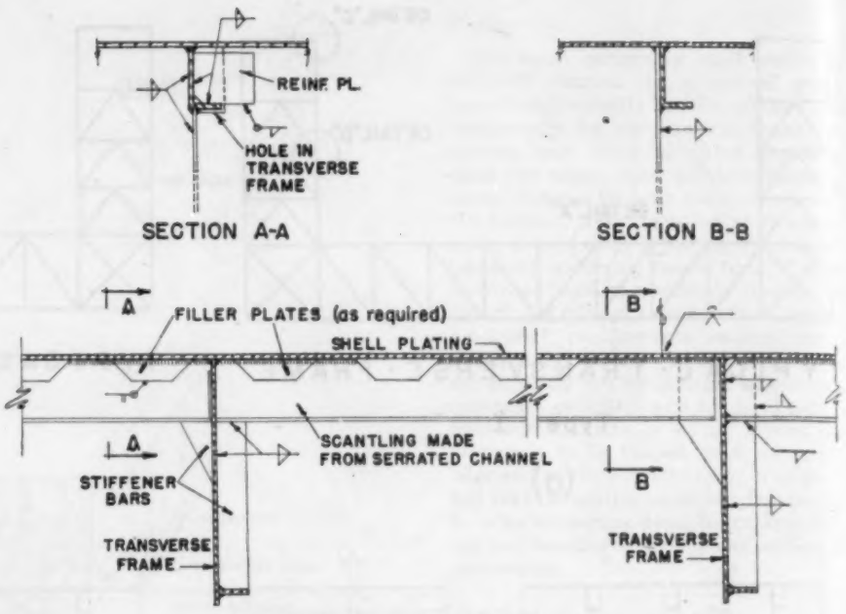


Fig. 7—Connection Details of Scantling

also utilized. A triangular arrangement of truss webbing is generally used for the sidewall frames. The webbing, however, is omitted above the safety deck to provide operational clearance, thus rendering the framing a composite truss-Vierendeel bent. In the pontoon, the web is arranged to form either a Pratt or Warren truss, as shown in Figs. 5 (*a*) and (*b*).

The section of the truss chord and the web members is dependent on the adopted method of interconnection and the jointing details. In general, the various methods of interconnection may be grouped under two headings: (1) lap type and (2) butt type. The simplest way of connecting the web members to the chords is by lapping, as shown by three types of details in Figs. 5 (*c*), (*d*) and (*e*). When this type of jointing is used, the choice for the chords will be L sections and preferably Ts for the web members. If the chord stresses are relatively small, as in the case of sidewall frames, a T section may also be utilized for the chords in which case the web members are connected by means of gussets welded on the backs of the Ts, as illustrated in Fig. 5 (*f*). For the pontoon frames, the chords may consist of either Yoder mill sections or built-up Ls. The other method of interconnection, the butt type, is illustrated by the typical detail of Fig. 5 (*g*). As will be noted, here the web members are fitted between the chords. In this type of framing, the web members will consist of either H or T sections, while the chords will consist of Ts, either split from H sections or built up by two plates. In comparison with the lap type of connection, the butt type is more difficult for fit-up and welding. On the other hand, the butt type has the advantage over the lap type in obviating secondary stresses due to the eccentricities of lap connections.

Bulkheads

Bulkheads are stiffened plates, designed primarily for maximum differentials of hydrostatic pressure between two adjacent compartments. The stiffeners will usually consist of serrated channels. However, in some cases L or T sections may also be utilized.

Welding and Jointing Details

The work involved in the welding of a drydock framing will obviously vary in accordance with the fabricating facilities of the contractor and the adopted method of assembling. There are, however, certain basic details which are characteristic to this type of framing.

Type of Welding and Electrodes

While automatic welding is utilized to varying extent by various fabricators, jointing is accomplished principally by manual welding. The specified electrodes conform to A.W.S. Specs. E-6010, E-6011, E-6013, E-6020 and E-6030.

Shell Splices

Typical details of shell plate welding are shown in Fig. 6. As will be noted, these are butt type complete-penetration welds. Except for the splices in the bottom plating of the pontoon, no difficulty is encountered in welding the seams from both sides. In the case of the bottom plating, when the method of assembly does not provide accessibility

Fig. 8—Partial View of Yard Showing Fabrication, Shell Panels and Wall Assemblies

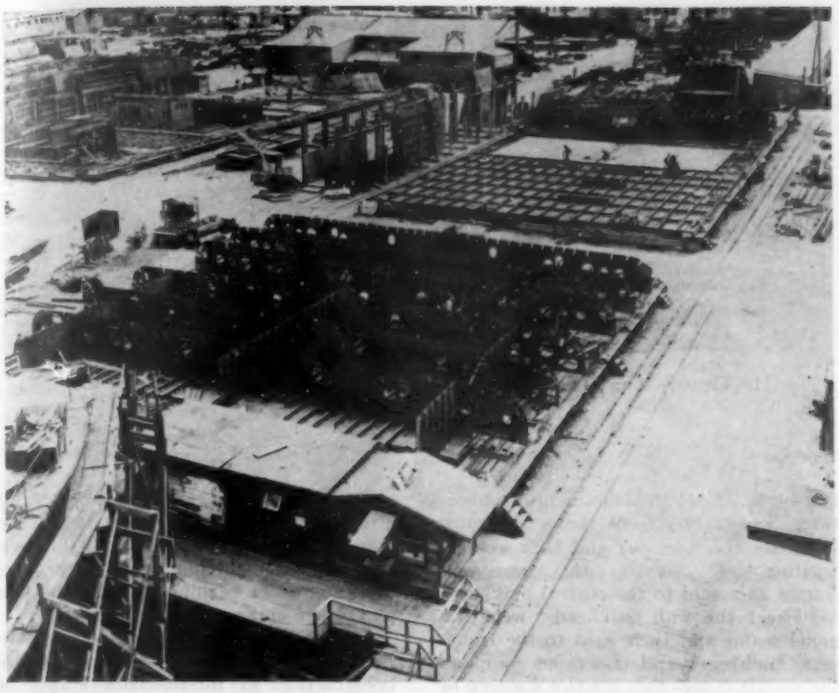


Fig. 9—Partial View of Yard Showing Fabrication of Pontoon Assemblies

from both sides, complete fusion is obtained by enlarging the joint gap and welding against a backing strip.

Scantling

The connection of the scantling to the shell plating is made by means of double-fillet welds. The serrated sections are particularly adaptable to manual welding, since the welding is intermittent and an all-around weld is required for each serrate. Where automatic welding is utilized, it is more advantageous to use split channels or angles for scantling, connected to plating by continuous welding.

The details of connection of scantling to frames are shown in Fig. 7. At one end the stringer is directly connected to the truss chord, while at the other end use is made of a bracket plate. In the intermediate supports, where the member passes through openings of the chords, the connection is made by means of a doubler and stiffener plate. All-around welds are used throughout to provide sealed connections.

Frames and Bulkheads

The jointing of the frames and bulkheads to the shell plating is usually made by continuous double-fillet welds. In some cases, however, grooved welds are also utilized with a view to obtaining a better joint from the standpoint of watertightness, although at a somewhat increased cost.

Truss Webbing

In devising connections for the web members of truss frames, the designer is guided by two basic considerations. Firstly, the chosen details must provide adequate clearance for assembly and accessibility for ease of welding. If a butt-type web framing is used, such as in Fig. 5 (*g*), there will be but little choice in detail to give the desired accessibility at all points of jointing. It will also be necessary to deposit weld from both sides or faces of the members. On the other hand, if a lap type connection is used, the choice will be between the details shown in Figs. 5 (*c*), (*d*) and (*e*). It is to be noted, however, that all single member lap connections are inherently eccentric and subject to the other consideration of design, namely, secondary stresses in the framing induced by the eccentricities of jointing. These additional stresses are primarily in the nature of local torsion in the chords and the accompanying longitudinal bending which affects both the scantling as well as the webbing. In addition, there may be also some bending in the plane of the truss due to possible eccentricities in that plane. If a Pratt truss framing is used, the choice will be between the two details shown in Figs. 5 (*c*) and (*d*). In this choice, the additional cost involved in specially shaping the ends of the web members in the former method must be weighed against the increased stresses due to joint eccentricities of the latter method. Generally, Method 1 will be found more economical. In the case of Warren truss framing, a concentric joint detail is usually obtained without the necessity of special end cuts. A typical joint detail illustrating this case is shown in Fig. 5 (*e*).

The welding details for sidewall frames are somewhat simpler. In the top panel, above the safety deck, where the web members are omitted to provide clearance, the provided joints are similar to those used in rigid framing. In the other panels, corner gussets are utilized for connecting the web members to the chords. The details *C* and *D*, shown in Figs. 5 (*f*) and (*h*), illustrate the two typical types of joints.

Welding Assemblies

The construction work of the floating dock involves three main operations: (1) fabrication of plating and frame members, (2) preparation of welding subassemblies and (3) erection and welding of subassemblies for final assembly.

The fabrication consists primarily of cutting the members to proper dimensions and preparing the edges for welding. Where use is made of serrated sections, the work will also include the punching or burning of channel sections to provide the desired serrates.

The next operation, the preparation of subassemblies, consists of putting together a number of fabricated members to form pre-erection units. The purpose of fabrication of subassemblies is to perform a part of the total welding work required for the completion of the framing in more accessible and controllable positions. These units are assembled in the erection yard or in the fabricating shops. The extent of subassemblies and the method of fabrication may vary rather widely at different yards in accordance with the available welding and handling facilities. At one place, the equipment may consist of a few derricks, while at another location it may include not only most elaborate weight lifting and handling devices but also special assembly jigs and welding positioners.

One of the simplest types of subassemblies commonly utilized in fabrication is shown in Fig. 4 (*a*). It is a shell panel, consisting of a segment of skin plating and the attached scantling. The im-

Fig. 10—Construction of Drydock by Use of Subassemblies, Showing Framing at Early Stage of Erection

portance of these panels is brought out by the fact that about 80% of the total weight of the steel framing is represented by the plating and the scantling. Furthermore, the amount of welding per unit of weight for these panels is considerably larger than the average figure for the entire framing. The size of the panel will vary in conformity with the handling facilities. The scantling is attached by either manual or automatic welding, with or without the aid of positioner. Similar assemblies are also utilized for bulkheads and solid-web frames. At some yards, where the program of construction involves several docks, the fabrication of these units is carried out on a large scale, with the care and planning of a mass production. Figures 8 and 9 show partial views of such a yard layout.

Segments of truss framing constitute another group of subassemblies which are often used to advantage in the erection of a dock framing. Here again the number of chord and web members composing such units vary.

Still another type of preassembly, which is perhaps the most advanced and impressive from the standpoint of construction technique, is represented by the so-called box or cellular assemblies. These units are formed by small subassemblies of shell plating and interior framing, and are often referred to as main assemblies. Dimensionally these units may be as long as 72 feet and weigh as much as 40 tons. While this method of fabrication will reduce the in-place or field welding of the final assembly to a minimum, the use of these units will also require extensive yard facilities and elaborate weight handling equipment. Figures 8 and 9 show some examples of this type of assembly, including sidewall units and pontoon segments.

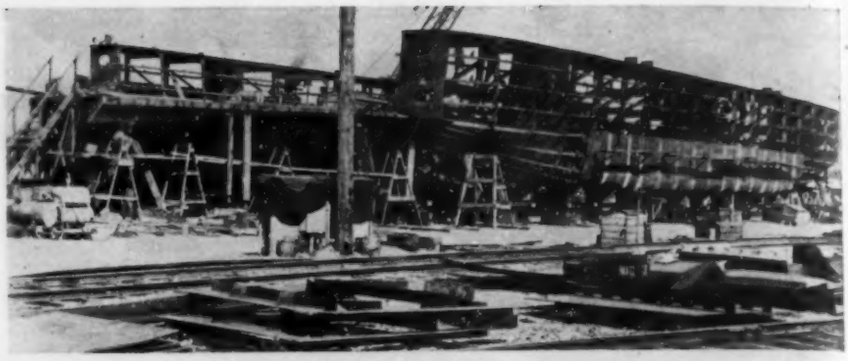


Fig. 11—Construction of Drydock by Use of Subassemblies, Showing Framing at an Advanced Stage of Erection

Welding Sequence and Erection Procedure

There is no standard procedure for erection of dock framing. Each fabricator is allowed to choose his own method of assembly predicated on his own experience and available facilities. The main requirements of the job are that the welding be sound, the jointing watertight and that the final assembly remain within reasonable tolerances of alignment.

The dock structure is erected in its upright or vertical position, and the assembly is based on a set of building ways located either at the launching site or in a basin. The general sequence of erection is to assemble the pontoon framing first, then proceed with the erection of the sidewalls. The erection and welding in each part begin at the center and progress toward the free ends. The more detailed procedure is as follows:

A. Erection by Subassemblies

(*a*) *Pontoon.*—(1) Place the bottom plating and weld the transverse and longitudinal seams, starting at the center and progressing outward in two directions, that is, fore and aft and port and starboard. (2) Erect the center longitudinal bulkhead and the transverse bulkheads and weld the splice seams first in each bulkhead then at the interconnections, progressing from center outward. (3) Place the scantling and tack weld in position. (4) Set up the transverse frames and weld to the central bulkhead. (5) Erect the wall bulkheads, weld the panel seams and then weld to the transverse bulkheads and trusses to complete the so-called egg-crate interior framing of the pontoon. (6) Weld the scantling to bottom plating. (In some cases bottom plating strakes may also contain the scantling to form panel subassemblies prior to erection.) (7) Place the top plating panels and weld the transverse and longitudinal seams, progressing from center outward in both directions. (8) Weld the frames and bulkheads to top and bottom plating simultaneously, starting at the center and working outward in both directions. (9) Weld the scantling to trusses and bulkheads to complete the welding of the pontoon framing.

(*b*) *Sidewalls.*—(1) Erect frames. (2) Erect shell panels and tack weld to the frames. (3) Erect and tack weld deck panels. (4) Weld plating to each other and to frames beginning at the bottom and progressing upward and outward.

Figures 10 and 11 illustrate an assembly by this method, showing two docks under construction at intermediate stages of completion.

B. Erection by Main Assemblies

Erection by this method consists of placing successive pontoon segments on the assembly platform and welding together in a restraint-free sequence, from center outward. In joining two adjacent units, the seams in the top and bottom plating are welded first, by simultaneous progress, followed by the welding of vertical joints from bottom up. After the completion of the pontoon welding, segments of sidewall assemblies are similarly erected and welded together by

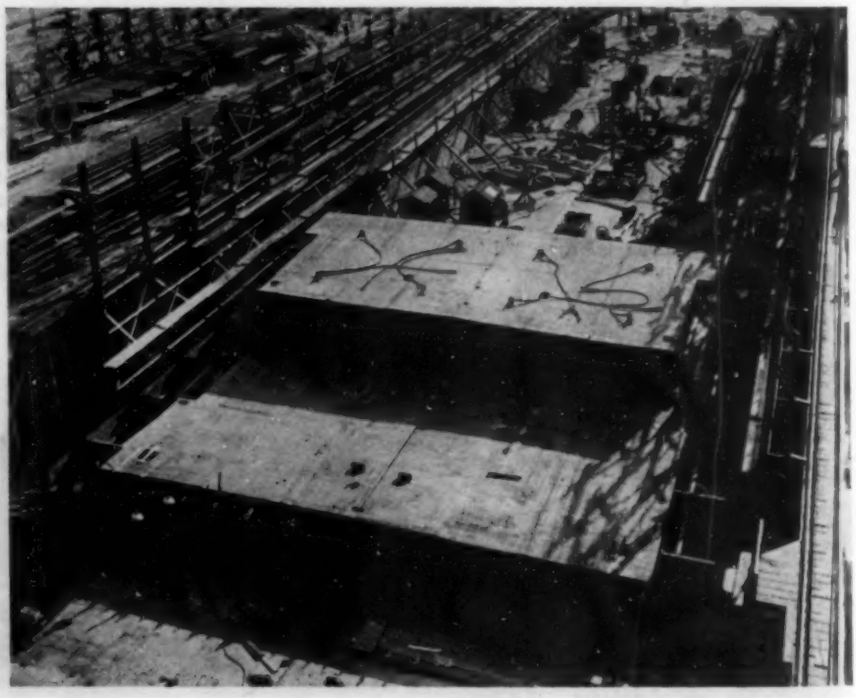


Fig. 12—Construction of Drydock by Use of Main Assemblies, Showing Large Pontoon Units

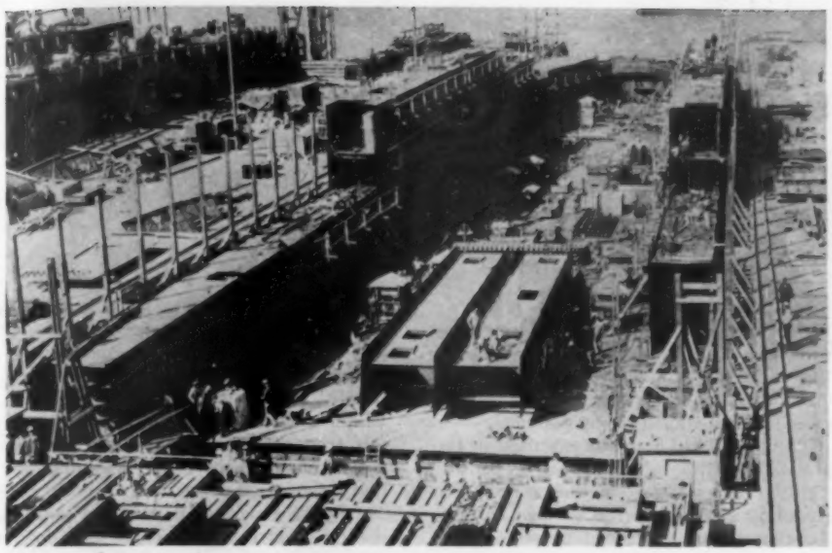


Fig. 13—Construction of Drydock by Use of Main Assemblies, Showing Erection of Sidewall Units

following the general procedure of beginning at the bottom of the walls at midship and progressing upward and fore and aft.

As a modification of this method of erection, in some cases bottom plating is not included in the pontoon assemblies, but is erected and welded in a sequence similar to the preceding method of assembly, after which, balance of the erection is carried out as outlined above. Figures 12 and 13 illustrate erection by the use of main assemblies.

Control of Alignment and Welding Quality

Good alignments are somewhat difficult to obtain in welding a dock framing. While local deformations in subassemblies are easily straightened by changing the welding sequence or by applying flame, the control of such distortions during the final assembly requires not only special care in the choice of welding sequence but also a certain amount of experimentation. When using the two methods of final assembly and welding as outlined above, the dock pontoon tends to cup upward. This tendency is more pronounced in the longitudinal direction than transversely, and is larger when using subassemblies for erection than when using main assemblies. In the case of the former method, experimentation discloses that if the welding of the interior egg-crate framing to bottom plating is lagged with respect to the top plating, the upward cupping tendency of the pontoon could be arrested and even reversed. Similarly, it is found that during the welding of the sidewalls additional upward deflections of the pontoon in the longitudinal direction can be obviated if the welding sequence of the sidewall plating is altered to begin at the top and progress downward and outward from the center, completing the last horizontal seam at the bilge.

In the other method, erection by main assemblies, the one satisfactory way for assuring proper longitudinal alignment is to erect the pontoon on a downward curving base, that is, to drop bow and stern with respect to the midship, and allow the ends to rise and level up during welding. The rate of pickup, obtained experimentally, is about 1 in. per hundred feet of longitudinal assembly.

Control of weld quality during the final assembly, particularly in the seams of the shell plating, constitutes an important task, requiring diligent inspection of workmanship. As a further aid in detecting defective welds, simple plug coupons are removed from the seams for etching and examination. When defects are disclosed, the affected seams are chipped out to sound metal and rewelded.

Watertightness of the shell seams and the bulkhead and deck plating is checked by subjecting each compartment to a compressed air test. If there should occur an appreciable drop in the air pressure indicating leakage, a soap suds solution is applied to the seams to detect the leaks. Further tests are made by submergence after launching of the dock.

Development of Technique

The welding design and the fabrication procedure of this unique undertaking were developed almost entirely during the war, without the benefit of any precedents. The success of the program was due, in a large measure, to the fresh approach to the problem, unhampered by existing rules and regulations. The rather daring designs and the new methods of fabrication are now fully justified by the proved performance of seaworthiness of these docks. It is hoped that the experience gained in design and fabrication of these structures will be used to great advantage in future work of other water craft planned for peacetime construction.

(*Continued from page 914*)

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(*Continued on page 952*)

Microstructure of Hard-Facing Alloys*

By H. W. Sharp†

THE use of hard-facing alloys to provide greatly increased life for metal surfaces subject to abrasion, corrosion and impact is today common practice in countless industries, from agriculture to steel mills. The parts so treated may weigh a few ounces or several tons.

Hard-facing alloys are of many types, each specifically designed to provide characteristics best adapted to combat the destructive forces to be met in a given operation. Whenever any type of mechanical operation is being performed, moving parts involved will be subject to wear and resultant loss of metal. Through hard facing all kinds of wear can be minimized. Hard-facing alloys are widely used not only for the protection of new parts to insure greater efficiency, but as a repair measure on worn equipment. When the proper type of hard-facing alloy is applied in the correct manner, a worn part will invariably outwear the ordinary steel replacement part with the result that maintenance cost is lowered and output is increased. Although the general use of hard facing is becoming greater all the time, there are still numerous possible applications which have not been exploited or even discovered. It is the purpose of this discussion to develop information which will enable a better understanding of hard-facing alloys and their physical properties.

In order to meet the various destructive forces at work in all kinds of industrial operations, there must be different hard-facing alloys. Some alloys must be resistant to extreme earth abrasion, some must resist the galling action of a dry bearing, some must be able to maintain relatively high hardness at elevated temperatures, and there are other requirements too numerous to mention. No single alloy or grade of hard facing can combine all the properties necessary to meet all conditions. As a result there are many hard-facing alloys and rods, which for simplification can be broken down into four broad types.

First of the four groups includes iron base materials containing less than 20% alloy. The term alloy is used to include all elements not generally found in the normal range for steel. Group 1 covers hard-facing rods with alloy content generally running from 5 to 14%, these elements being chromium, manganese and silicon, in addition to high carbon and perhaps small quantities of tungsten, molybdenum and nickel. This group of hard-facing alloys is relatively low in cost, and is designed primarily for electric arc application to large parts or heavy equipment. The alloy is designed to have relatively high hardness combined with toughness sufficient to resist moderate impact. Eleven to 13% manganese steel will fall into this category, but it is not generally considered as a hard-facing material.

The method of manufacture used in the production of Group 1 rods varies considerably. The simplest method is to apply a coating containing the various hardening alloys to a mild steel or plain high-carbon core wire. The coating serves not only as an arc stabilizer and a slag former, but also the alloy carrier. Alloy-coated rods, however, are limited as to the amount of alloy which can be incorporated into the final weld deposit since there is a definite maximum percentage coating which can be applied to a rod. Another means of producing the low-alloy rods is by casting into sand molds or permanent molds; however, this method is generally too costly to compete in the low-alloy range. Group 1 rods, fabricated by placing of alloys inside a mild steel tube, permits the manufacture of relatively high-alloy materials by a low cost method. Percentage of alloying elements can be controlled very closely and coating for electric application need be applied only for arc stabilization and fluxing.

Group 2 hard-facing rods, consists of iron base metals with more than 20% alloying ingredients, which may include chromium, tungsten, molybdenum, nickel, cobalt, boron, manganese, silicon, vanadium and zirconium. These rods contain from 20 to 50% alloys and hence are necessarily higher priced. Since alloy content is increased over Group 1 rods, Group 2 rods are generally harder and more resistant to straight abrasion, but do not possess as high a degree of shock resistance. Certain types of Group 2 alloys also possess a relatively high degree of red hardness but this is not one of the major physical properties. The hard-facing rods of this group are manufactured by casting into permanent molds or in sand molds. Due to high-alloy content this type of rod cannot be forged or hot drawn and, therefore, must be cast. Group 2 rods are furnished bare for oxyacetylene application or as coated electrodes for electric arc application.

Group 3 hard facing covers nonferrous alloys with principal ingredients being cobalt, chromium and tungsten with small amounts of carbon and deoxidizers such as silicon, manganese and boron. Group 3 alloys are produced in more than one grade or range of hardness. The softer grade

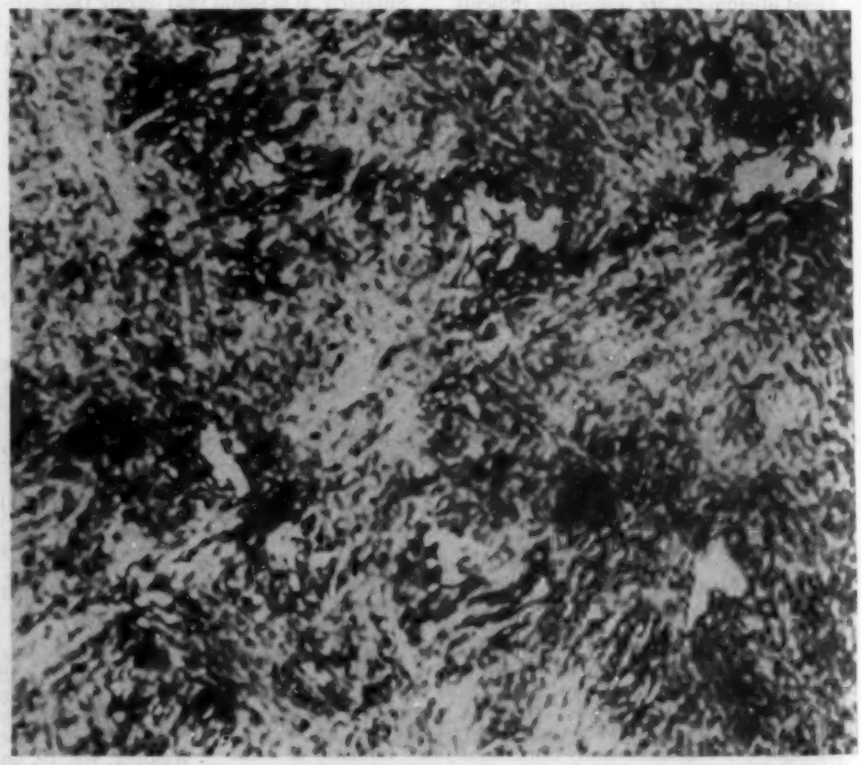

Fig. 1—Photomicrograph of an Alloy Typical of Group 1 Hard Facing; 1000 ×

* Scheduled for Twenty-Seventh Annual Meeting, A.W.S., Atlantic City, N. J., week of Nov. 17, 1946.

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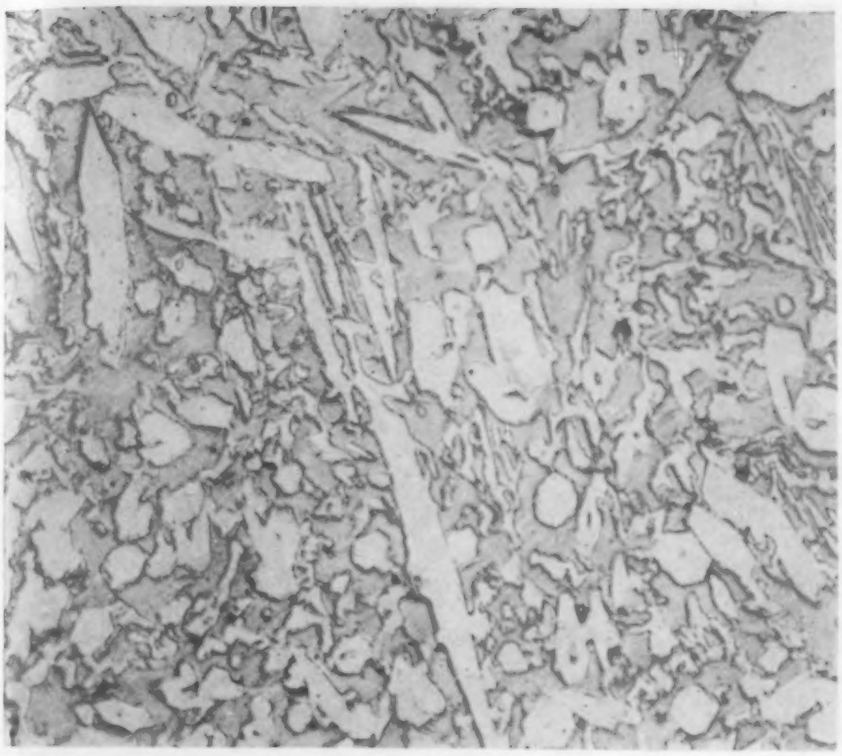


Fig. 2—Photomicrograph of a Group 2 Alloy; 500 ×

has good strength and toughness and can be machined with carbide tools. The harder grade has greater resistance to wear but less strength when subjected to severe impact or thermal shock. Both types are characterized by their resistance to heat and corrosion, being able to maintain nearly full hardness at red heat and losing no weight through oxidation at elevated temperatures. Ease of application comes through a combination of alloys which has a relatively low melting point, and which is fluid at molten temperature and yet resists oxidation during the welding process. A thermal coefficient of expansion quite similar to the common base metals makes possible perfect bonding with all steel. Since these alloys cannot be hot forged readily they are produced by casting into permanent molds or sand molds.

The fourth group of hard facing covers tungsten carbide contained in steel tubes. These rods are supplied with tungsten carbide particles accurately screened to nearly any mesh size desired. The carbide is manufactured by melting tungsten in the presence of carbon and casting into fingers or shapes which are subsequently crushed, ground and screened, and placed or rolled into steel tubes. Since the carbide particles are not melted by an oxyacetylene flame, deposits from these rods are heterogeneous, the hard particles being held in a steel matrix. Tungsten carbide tube rods for electric application are produced by coating the particles with a refractory material which will protect them against the heat of the arc during welding. Tungsten carbide is also cast into small shapes to be used as inserts which are welded into drilling bits, etc. The Group 4 alloy must be considered separately from the other three types in that it is heterogeneous in nature.

In reviewing the first three groups of hard-facing rods it can be seen that there are two factors which are common to all the alloys. All have Rockwell hardness values which are relatively close and are within the range of hardness for heat-treated, plain-carbon steel. Even the hardest alloy in the first three groups has a Rockwell no greater than can be attained by quenching a plain high-carbon steel, yet any of the hard-facing alloys will outwear high-carbon steel from 2 to 20 times. This indicates that Rockwell hardness is not the controlling factor when determining relative wear resistance. All of the hard-facing rods in the first three groups contain chromium as an alloying element in an amount of from 5 to 35%. All of the rods contain carbon in excess of 1% and even as high as 4½%. It is a known fact that chromium combines very readily with carbon to form any one of a number of complex chromium carbides. The various common carbides have similar physical properties in that they are extremely hard and relatively brittle.

Hard-facing alloys cannot be compared on a Rockwell hardness basis and it is difficult to compare alloys from an analysis standpoint. A study of microstructure provides a means of explaining superior wearing characteristics of hard-facing deposits over other metals and comparing the various hard-facing alloys to one another.

Figure 1 is an alloy typical of Group 1, the under 20% alloy group. This is an iron base metal containing 7% chromium, 3½% manganese, 1½% carbon and small amounts of silicon, molybdenum and zirconium. The application is generally made by the electric arc using coated electrodes. The weld metal is air hardening and will average 52–55 Rockwell C. The photomicrograph, at 1000 diameters, shows the structure to be pseudo-martensitic with scattered particles of chromium carbide. (The white areas are the complex carbide—this has been determined through the use of special etching reagents which will attack constituents containing a concentration of chromium carbide.)

A pseudo-martensitic structure means one that is similar to the common mar-

Fig. 3—Photomicrograph of Lower Hardness Cobalt-Chromium-Tungsten (Group 3 Alloy); 500 ×

tensite which is obtained by quenching a high-carbon steel. It differs from the normal martensite in that the needles are much smaller in size and they are held in an austenitic matrix. This is determined by etching rate when the usual acids or etching reagents are used. It is the retained austenite which accounts for an increase in impact resistance over heat-treated plain-carbon steel of the same hardness. The wear resistance factor can be explained by the presence of chromium carbide particles distributed throughout the mass. Because of its grain structure it can be welded to either carbon steel or manganese steel parts successfully. When applied to heavy industrial parts, life is increased from 2 to 5 times over original or factory replacement pieces. The hardness and microstructure of the alloy are virtually unaffected by heat treatment. The alloy is designed to resist abrasion and impact encountered on such equipment as tractor parts, power shovel buckets and teeth, roll crushers and all heavy industrial equipment which must "take a beating."

Figure 2 is a photomicrograph of a typical deposit of Group 2 rods—the over 20% alloy group. This shows the structure of an iron base alloy containing 33% chromium, 7% manganese, 4% carbon with small amounts of zirconium and silicon. The deposit has a Rockwell hardness of C 56 to 58. The photomicrograph is at 500 diameters. The white islands are a complex chromium carbide, and the matrix consists of most of the iron and manganese with some of the chromium dissolved. Actually the islands are needles intermixed at all angles. The alloy is considered as a homogeneous mixture whereas actually it is a two-phase material with hard chromium carbides held in a relatively hard matrix. The particles are very small in size, as indicated in the photomicrograph. They are smaller than the grains that go into making up the structure normally found in steel. We know the white areas are chromium carbide by selective etching. It is the chromium carbide which takes the brunt of the wear load and these particles have sufficient strength and backing so as not to break off or crumble when subjected to sliding abrasion. It is the concentration and positioning of carbide particles in the deposit which makes a wearing surface superior to other types of hard-facing deposits where a smooth, highly polished surface is required. In service, when subjected to earth abrasion, as on a plowshare or other agricultural implement, the surface will become highly polished. Since the carbide particles are extremely hard and the matrix is sufficiently rigid to hold them in place, deposits of Group 2 alloys exhibit very low coefficient of friction. It is due to this fact that excellent bearing surfaces can be made by hard facing with these high-alloy materials. With the high percentage of chromium contained in alloys of Group 2 these materials can be considered as stainless, having good resistance to corrosion when in contact with the common corrosive media, but they should not be used where corrosion is the prime factor.

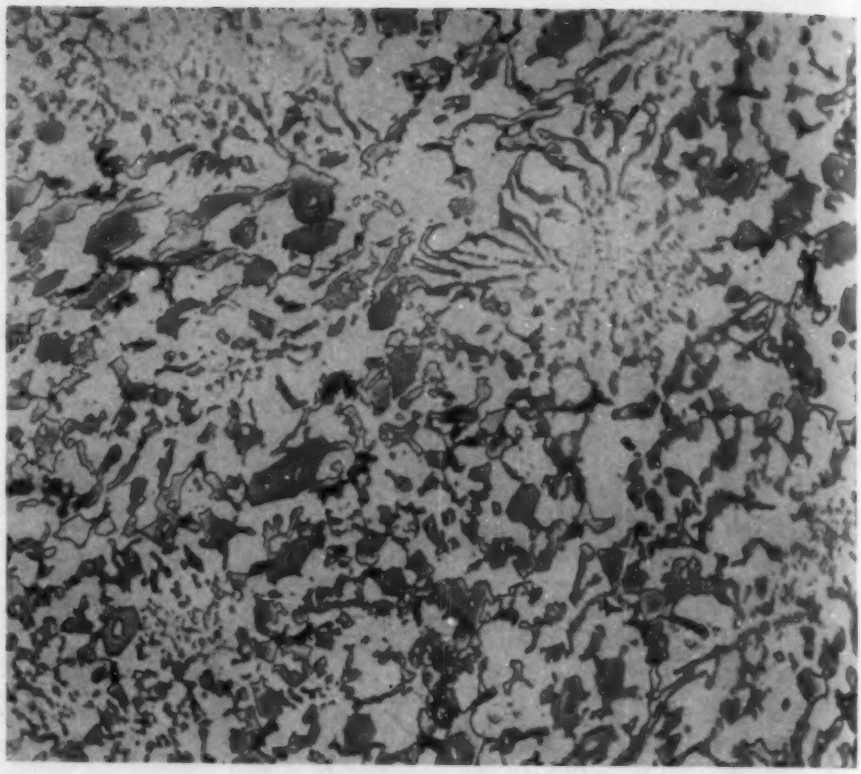


Fig. 5—Photomicrograph of High-Hardness Cobalt-Chromium-Tungsten Alloy; 500 ×

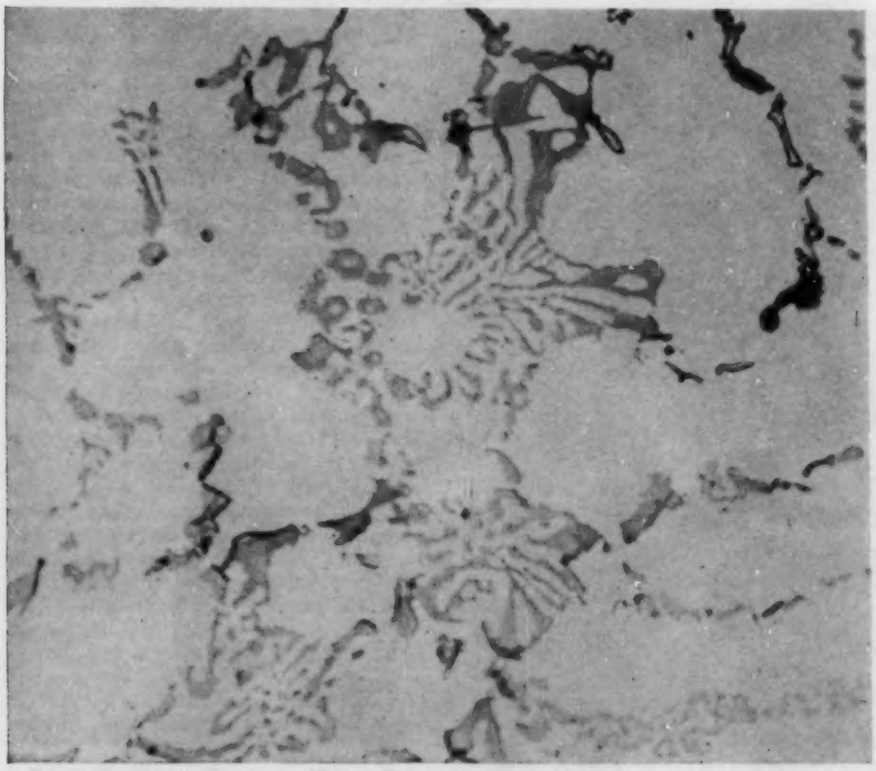


Fig. 4—Same as Fig. 3 at 1000 ×

Figure 3 is a photomicrograph of a nonferrous material which falls into the Group 3 classification. The alloy is made up of roughly 25% chromium, 5% tungsten and the balance cobalt with 1% carbon and a small amount of silicon. The hardness of the alloy is Rockwell C 42 to 44. The photomicrograph shows the structure at 500 diameters. There are actually 3 phases represented here—the gray constituent is a complete chromium carbide whereas the darker particles, of which there are only a few, are a complex tungsten carbide compound.

Figure 4 shows the same structure at 1000 diameters and the various phases can be more easily identified. Here the chromium carbide shows up as a gray constituent whereas in the Group 2 alloy the car-

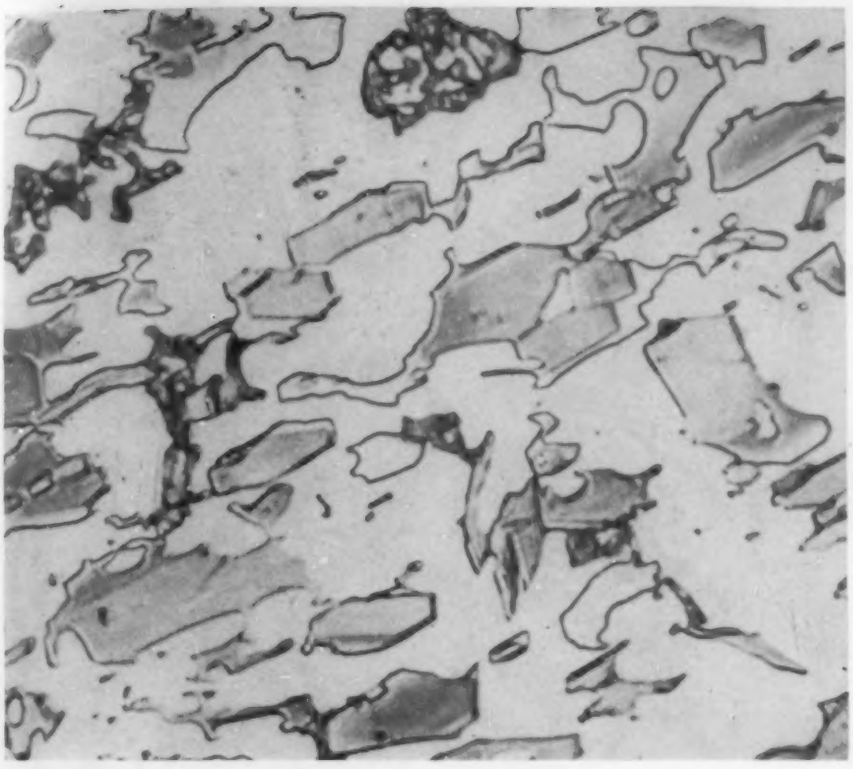


Fig. 6—Same as Fig. 5 at 1000 ×

bide was white. This is due to the fact that different etching reagents were used on the two metals to bring out contrast between the various phases present. The white background or matrix is the cobalt containing some of the chromium and tungsten in solid solution form. A relatively high tensile strength can be obtained in deposits of this Group 3 material —125,000 psi. is the average of many tests made using both centrifugally cast test bars and welded specimens.

In addition to its tensile strength, the alloy will have 1 to 2% elongation. Since the material has a small amount of ductility it can be applied to base metals which must undergo a heat treatment subsequent to welding. An oil or water quench will not affect the Rockwell hardness nor wear resistance since there is no change in structure through heat treating. The nonferrous group of alloys is characterized by other noteworthy properties which include resistance to corrosion and oxidation, and a high red hardness. These properties are derived from the fact that cobalt is a noncorrosive element particularly when combined with chromium. Since there are no connecting grain boundaries in the cobalt-rich matrix there are no channels for progressive grain boundary disintegration to occur when in contact with corrosive media. If an alloy is made up containing all the major ingredients but leaving the carbon out, the result will be that none of the dark constituents will be present. The chromium and the tungsten will exist in solid solution in the cobalt resulting in a single-phase material with a Rockwell C hardness of approximately 28. The wear resistance will be definitely decreased along with the drop in hardness The major contributing factor in wear resistance is the presence of the carbides.

Figure 5 shows another alloy at 500 diameters falling in the nonferrous Group 3. This material is a sister metal to the one that has just been examined. The difference is that it contains 13% tungsten and 2% carbon, with the same amount of chromium. The major change in microstructure is an increase in the amount of carbides present. There is a much greater percentage of the tungsten carbide compound with approximately the same amount of chromium carbide as found in the other alloy. Figure 6 shows the same material at 1000 diameters. The alloy has a Rockwell hardness of C 52–54 with a corresponding increase in wear resistance over the softer grade. Tensile strength in this alloy will average 90,000 psi. and there is no measurable elongation. The high hardness alloy has corrosion-resistant properties similar to the other metal of the same group, but where corrosion resistance is the prime factor involved in applying hard facing, the lower hardness grade is generally recommended.

Figure 7 shows the microstructure of a deposit of a Group 4 rod—the tungsten carbide group. The photomicrograph is taken at 50 diameters. Here the particles of the cast tungsten carbide are embedded in a relatively soft matrix of steel. Cast tungsten carbide has a melting point of approximately 4600° F. and it is due to this fact that very little of the carbide dissolves in the steel matrix during oxy-acetylene application. In normal application of tube tungsten carbide less than 5% of the carbide will be dissolved. This action is beneficial to a degree in that small additions of tungsten and carbon to the steel matrix increase the hardness very markedly thus providing a harder binding material for the carbide particles. At the interface between the carbide and matrix there are a number of small particles of iron tungstide, the compound Fe_2W.

Figure 8 is a photomicrograph at 1000 diameters which shows the interface more clearly. The particles of iron tungstide are distinguished by their shape as well as

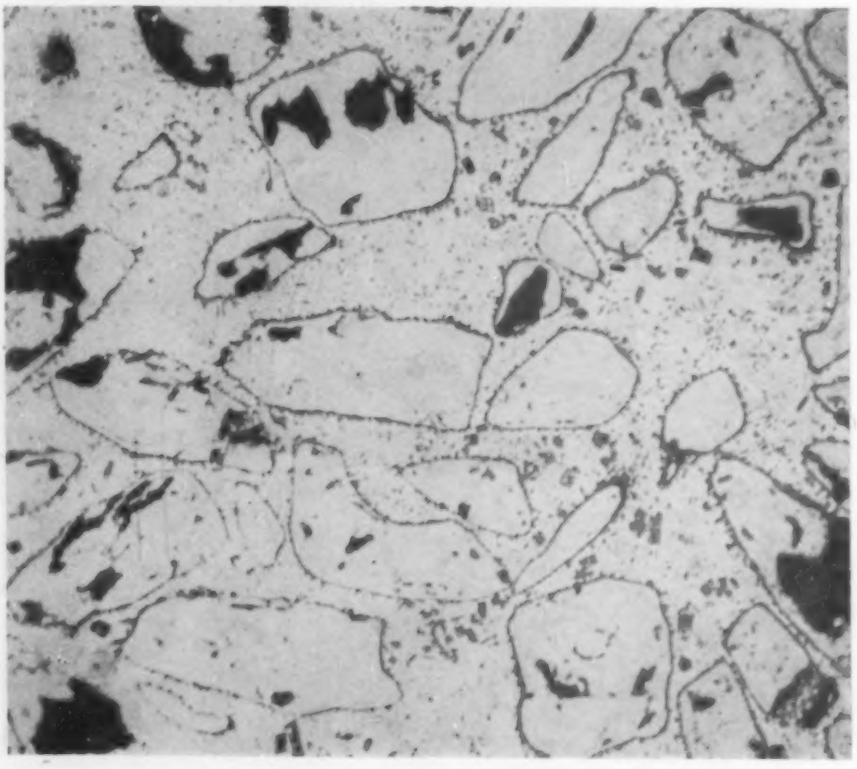


Fig. 7—Photomicrograph of Tube Tungsten Carbide Deposit (Group 4); 50 ×

through selective etching. The normal structure found in steel does not show up in the matrix because etching reagents used in bringing out the carbide and tungstide constituents do not attack ferritic grain boundaries.

There are two compounds formed in the tungsten-carbon system. The first is W_2C and contains 3.2% carbon—the second is WC which contains 6.2% carbon. The first carbide is characterized by high hardness with relatively good toughness whereas the second carbide has extremely high hardness and is very brittle. The two compounds combine in a solid solution to give an alloy which has relatively good toughness with very high hardness. An alloy containing 4.2% carbon has proved to be the best combination in wear resistance and toughness. The tungsten carbide is manufactured by the melting of pure tungsten powder in carbon crucibles with accurate control as to time and temperature. The metal is cast into shapes which are readily crushed. After crushing, the particles are screened to various sizes and placed or rolled into mild steel tubes. Various sizes and shapes of tungsten carbide inserts are also made for use on drilling bits for higher cutting efficiency. Group 4 hard-facing rods have proved far superior to any other type of hard facing for resisting straight earth abrasion. The life ratio of tungsten carbide faced parts to steel parts is greater than 20 to 1. These rods find greatest application and universal acceptance on such parts as oil well drilling bits, grader blades, muller plows, ditcher teeth, etc. The heterogeneous alloy is not applicable to such parts as bearings where the wearing surface must be smooth.

In order to explain more thoroughly the reason why hard-facing alloys are capable of extending service life of industrial equipment in comparison with steel parts heat treated to give comparable or even greater Rockwell hardness readings, further study has been made through the use of a microhardness tester. This instrument consists of a small, perfectly ground diamond point which can be impressed upon a polished surface under a given spring load. The diagonals of the diamond impression so made are measured under the microscope, and by using a simple formula, Vickers hardness reading can be calculated. The Vickers values are then converted into the better known Rockwell hardness scale by conversion tables. With the microhardness tester, comparative hardness values of various constituents in the microstructure can be obtained accurately. Figure 9 shows two of the diamond impressions made with a 22-gram spring load. The photomicrograph, taken at 1000 diameters, shows one impression on a tungsten carbide particle and one in the steel matrix material. The impressions, measured and converted into hardness readings, give a value of Rockwell C 45 for the steel matrix and a Rockwell of greater than C 86 for the tungsten carbide. It is impossible to obtain a true Rockwell test on a piece of tungsten carbide because it shatters under the relatively heavy load. The microhardness tests, however, can be compared with one another because all were made under identical conditions. A large number of readings gave values of C 84 to 88 on the tungsten carbide.

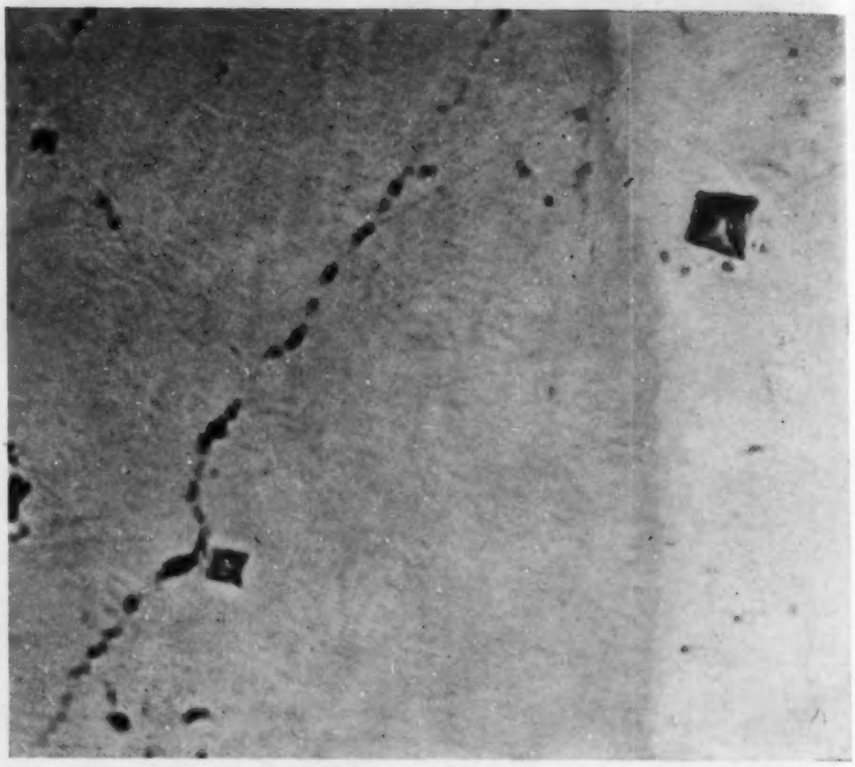


Fig. 9—Two Microhardness Impressions; One at Left in Tungsten Carbide Grain; At Right, Steel Matrix Material; 1000 ×

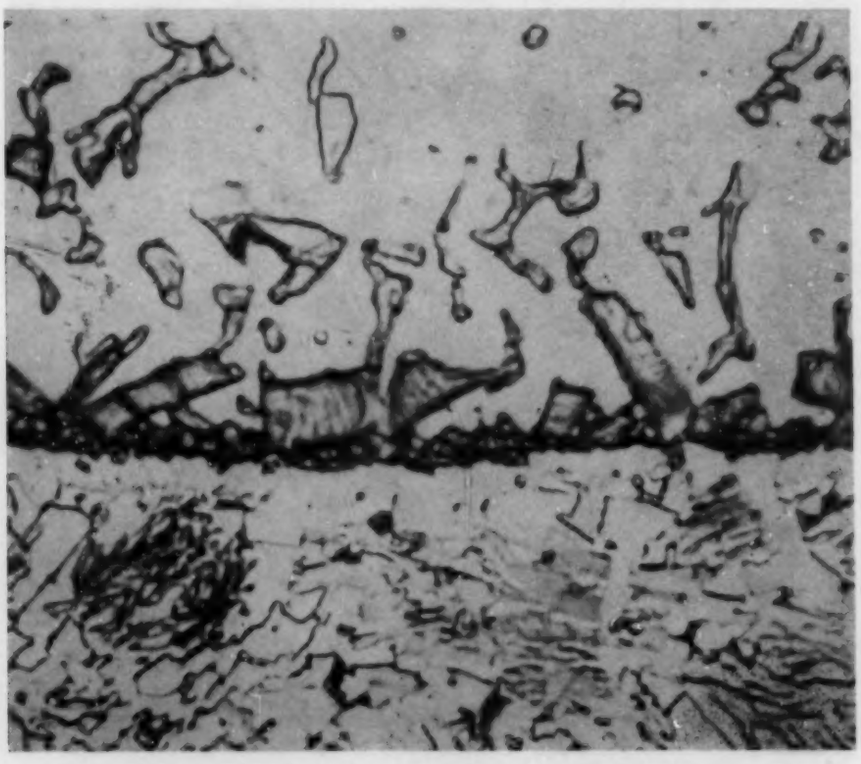


Fig. 8—Interface Between Tungsten Carbide Particle and Steel Matrix; 1000 ×

Steel matrix readings for this material varied from C 38 to 47 probably due to different percentages of dissolved tungsten carbide. With such an extremely high Rockwell on the tungsten carbide it is easily understood why the heterogeneous type Group 4 alloys are unsurpassed for straight abrasion.

In examining the microhardness of Group 2 rods, Fig. 10 shows two impressions at 1000 diameters made on the polished, unetched surface of the 33% chromium alloy discussed above. This deposit

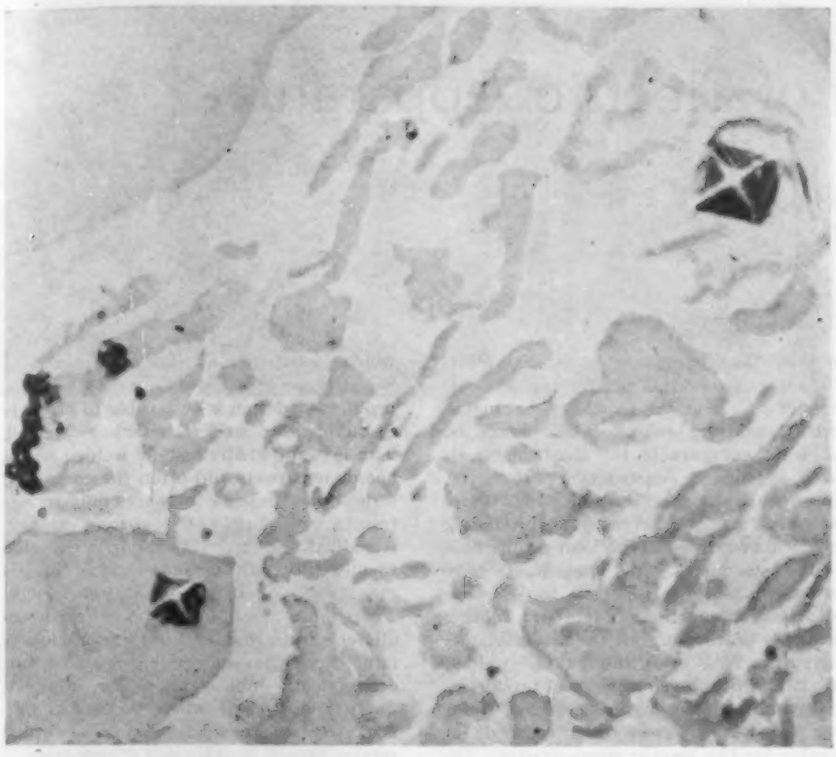


Fig. 10—Microhardness Impressions on Group 2 Alloy; 1000 ×

has a true Rockwell reading of C 56. The impression at the left is on one of the chromium carbide islands and has a value of C 75. The one at the right is on the matrix material and calculated hardness is C 52. It might be thought that since nearly one half the field is carbide and half is matrix, the resulting real Rockwell should be an average of hardness of the two constituents. This is not the case. Under the heavy Rockwell load the hard carbides are pushed down into the matrix so that the softer material is really supporting all the weight. This explains the reason why a hard-facing rod with a Rockwell hardness no greater than can be obtained by heat treating a high-carbon steel will outwear the steel part as much as 10 to 1. The same hardness relation exists in the nonferrous alloys of Group 3.

Figure 11 shows microhardness impressions at 1000 diameters in the lower hardness alloy. The large impression, in the white matrix material has a micro reading average of C 43, whereas impressions made in the gray complex chromium carbide have values of C 71. In this case the hard ingredients in the structure do not contribute to the actual Rockwell hardness of C 43 because of their distribution and size. Yet it is the hard particles of chromium and tungsten carbides which give the alloy its increased life over plain-carbon steel parts. Since the cobalt-rich matrix does not soften materially at elevated temperatures and is not subject to oxidation, this type of alloy is red hard and is applicable where the destructive forces of heat, corrosion and abrasion are present. In the harder nonferrous type of Group 3 rods microhardness values for the matrix average C 46, the gray chromium bearing constituent averages C 71, and the tungsten carbide constituent goes as high as C 79. Here the greater percentage of hard particles in the structure contributes slightly in raising the real Rockwell hardness to C 53. The greater percentage of hard particles helps to explain the fact that the alloy has relatively no ductility compared to the softer grade.

Group 1 hard-facing rods—those containing less than 20% alloy—have microhardness readings identical with the actual Rockwells except on the chromium carbide particles which are dispersed uniformly throughout the entire mass. The chromium carbide particles in the alloy are so small that microhardness impressions could not be made directly on that constituent. The structure of a fully hardened plain-carbon steel is entirely martensitic with Rockwell hardness values of 55 to 60 depending on carbon content. In this case the microhardnesses will correspond exactly with actual Rockwell readings.

In conclusion it is to be pointed out that all hard-facing deposits are heterogeneous in nature—being made up of uniformly distributed particles of various carbides held in a softer matrix. In the alloys of the first three groups, the particles are so small that for all practical purposes these materials can be considered as homogeneous. The hard particles are either complex chromium or tungsten carbides and in the case of Group 4 rods the particles are pure tungsten carbide. It is the microhardness of the hard constituents in the structure, their distributuon and size which accounts for a greatly increased resistance to wear over plain-carbon steels. The elements which go into the matrix material determine other physical characteristics such as resistance to heat, corrosion and impact. Knowing microstructure of hard-facing metals it is possible to predict physical properties and better prescribe hard-facing alloys and methods of application to meet any problem involving abrasion, corrosion and impact.

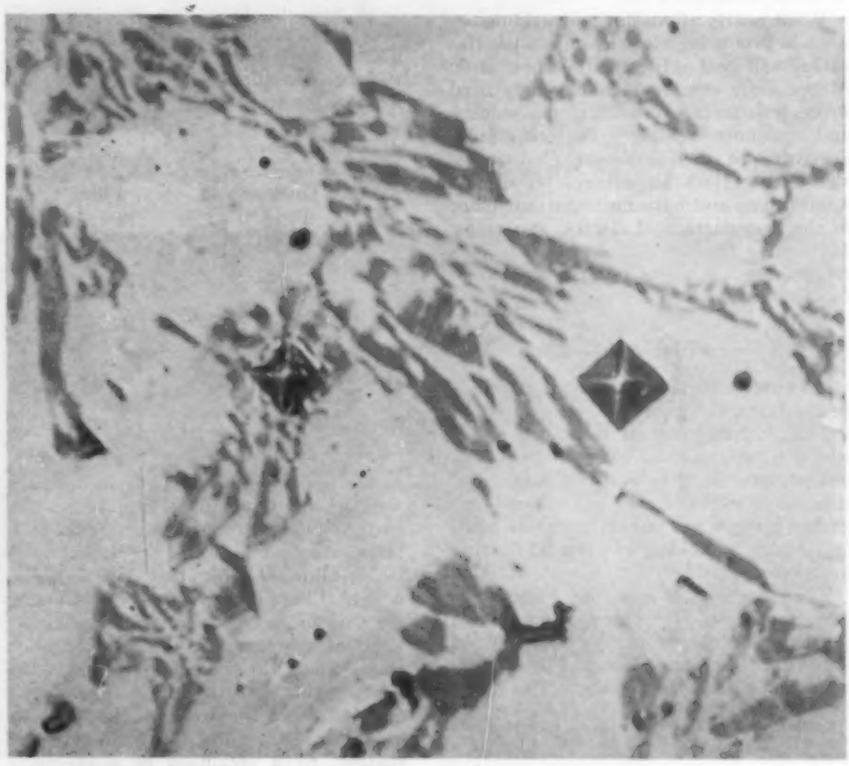


Fig. 11—Microhardness Impressions on Group 3 Alloy; 1000 ×

Welding of Electric Apparatus*

By E. F. Potter†

Introduction

THE manufacture of electric apparatus utilizes nearly every welding process in existence from that used by the blacksmith to the recently developed and more highly refined methods. Welding in its various forms has been, and will undoubtedly continue to be, largely responsible for the tremendous advancement and progress in the electrical industry. This modern engineering and production tool has made possible even greater progress in other fields, such as shipbuilding. Other industries, such as building construction are relatively untouched. Without question the transportation field has reaped the greatest reward by extensive use of welding. The outstanding accomplishments of welded construction have been made possible by the fact that welding permits maximum flexibility in design and the building of any structure of almost unlimited size, and is readily adaptable to production line methods. Along with these advantages, welding has brought heretofore unknown economies in material and production costs, thus, it is recognized by the electrical and many other industries as the primary process of metal fabrication.

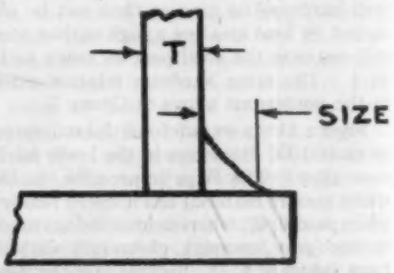
While nearly all methods of welding are used in producing electric apparatus, this article will deal only with the application of the more commonly and widely used processes: metal arc welding, gas welding and resistance welding. The other processes due to their inherent characteristics offer certain advantages on specific applications and have an important place in the manufacture of electric apparatus. In fairness to all welding processes, it is recognized that each has a legitimate and most useful field of application.

Engineering and Design

One prerequisite to the most effective, successful and economical utilization of welding is proper design together with the selection of material, selection of the welding process or processes and preparation of working drawings. These preliminary steps are just as essential when fabricating by welding as when fabricating by other methods.

The selection of suitable material is important, not only because it must have certain physical properties but welded joints in the material also must have satisfactory physical properties. This does not necessarily mean that welded joints in a given material must have physical properties identical to the base metal. Such conditions are ideal and should be at least comparable for most materials used in welded construction. However, there are many specific applications where materials are welded without producing physical properties in the joint comparable to the base metal. Yet these joints have proven entirely satisfactory for the applications in question. Metal arc welding of armor plate is an outstanding example. In such cases, even though the welded joint does not develop physical properties comparable to the material welded, welding still far surpasses other methods of joining for the specific requirements. On many structures made up of materials suitable for welding, the amount of welding or size of welds is limited to that needed for service requirements. As with riveting, if two rivets are sufficient, there is no need of using a dozen. The same reasoning applies equally as well to welding. "Over welding," or too large welds, often makes it more difficult and expensive to produce a structure to meet design standards than if a sufficient minimum of welding is specified. So far as possible, weld sizes are kept to a minimum consistent with quality welds and design needs. The following chart shows the suggested minimum fillet weld size permissible for arc welding.

Plate Thickness T	Fillet Size, In.
1/16	3/32
3/32	1/8
1/8	3/16
3/16	1/4
1/4	1/4
5/16	1/4
3/8	1/4
1/2 and up	5/16



One fundamental principle in design is to make sure the material is in a condition to function as we normally think of it functioning, as in a test specimen, or to make allowance for this in designing. A welded butt joint with 100% fusion and the reinforcement removed is probably the closest approach to the ideal condition and a fillet weld is a good example of the least favorable condition. The latter exposes either the weld or the adjacent base metal, depending on the direction of loading, to a condition of unfavorable stress concentrations. Even so, such welded joints are satisfactory for a large percentage of applications. The real problem in design is to be able to properly evaluate the materials when welded. This is best done by tests of welded joints, component parts and often the completed structure. In some instances only service results can supply the correct answer. A welded structure is, of course, expected to meet not only normal service requirements but conditions of extreme service. There must be a limit and one might logically conclude that if any structure never fails then it is overengineered and not economically built. There are, however, many applications where structural failure even under conditions of abnormal service cannot be tolerated at any price.

One essential considered in evaluating materials is to make sure a welding procedure has been established which will consistently produce known physical properties in the welded joint. The welding process must be applicable to the structural design, which makes it necessary to select the process or processes to be used before the final design. A design often makes use of several welding processes or a group of processes.

Shapes are another important factor in selecting materials. Gas cutting is extensively used in shape cutting parts and is accepted as an indispensable tool for use in preparing parts for metal fabrication. However, there are other methods which are used in preparing parts such as spinning, forming, forging, casting, machining and punching. These methods often prove practical and economical to make parts to the desired shape. Forming of parts to reduce the amount of welding is extensively used in welded structures. Welding, while relatively inexpensive, is expensive if used unnecessarily.

Selection of the welding process or processes to be used is an important item because a design for one process is not necessarily suitable for another. If the

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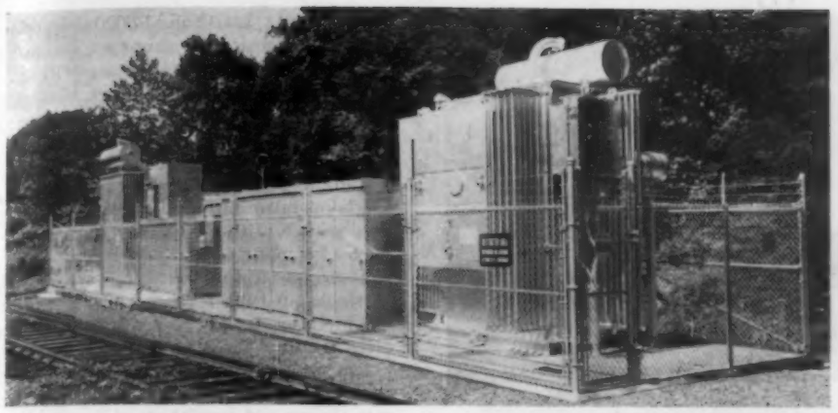


Fig. 1—Outdoor Unit Substations of Welded Construction

Fig. 2—Distribution Transformer Tank Fabricated by Resistance Welding

thickness of material, production requirements or some other dominant factor dictates a certain process, then this is an easy problem. However, to get the most out of any process requires a suitable design for the process, exactly the same as when changing from a cast to a fabricated structure or vice versa. The best approach as to which process to use is to recognize the inherent characteristics, limitations and possibilities of each process, much the same as is done with the two commonly used types of power supply, alternating current or direct current.

Both arc and gas welding are recognized as universal welding tools, each especially adapted to certain needs, even though this may be overlapping at times. In arc welding the temperature is high, the energy input to the arc can be of almost any magnitude and is highly concentrated. This suggests that the arc can be used in places where the heat must be highly localized and concentrated in a limited space. The electrode serves as a heating medium and usually as filler metal, either of which may be an advantage but can be a disadvantage.

Gas welding does not produce such a high temperature as the electric arc, the energy in the welding flame may be any desired quantity but is less concentrated and requires space for combustion. All of these characteristics suggest certain limitations and possibilities for each process.

Resistance welding is essentially a machine tool ideal for mass production. The science is built in to the machine and control and requires less operator skill, although certainly not less attention. The temperature produced by the energy input is that required for sufficient localized heating of the parts for welding. The heat is highly concentrated and localized and the energy input may be of almost any magnitude. For all methods of resistance welding a minimum space is required for the electrodes that conduct the energy to the parts for welding. Practical and economic considerations usually limit seam welding of pressure-tight joints to material thickness of $^1/_8$ in. or less.

In general, arc welding is used for welding materials from $^1/_{16}$ in. thickness to unlimited thickness and universally for materials $^3/_{16}$ in. and thicker, except piping 2 in. diameter or smaller.

Gas welding is used principally for piping or tubing 2 in. diameter and smaller and for material $^1/_8$ in. thickness or less.

Resistance welding is used mostly for repetitive parts. For pressure-tight joints employing seam welding, the thickness of material is limited to about $^1/_8$ in.; however, thicker materials have been welded. Spot and projection welding are used on thicker materials usually $^1/_2$ in. maximum. Flash welding is also used on thicker materials and is limited only by the cross-sectional area of the parts for which there is machine capacity.

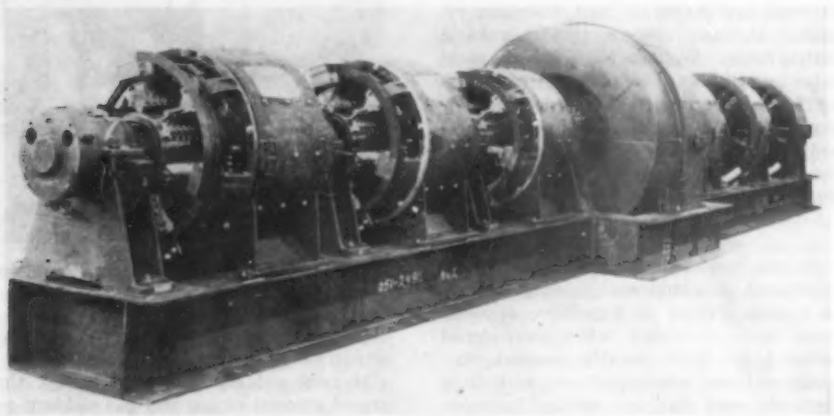


Fig. 3—Steel-Mill-Type Motor-Generator Set of Metal Arc-Welded Construction

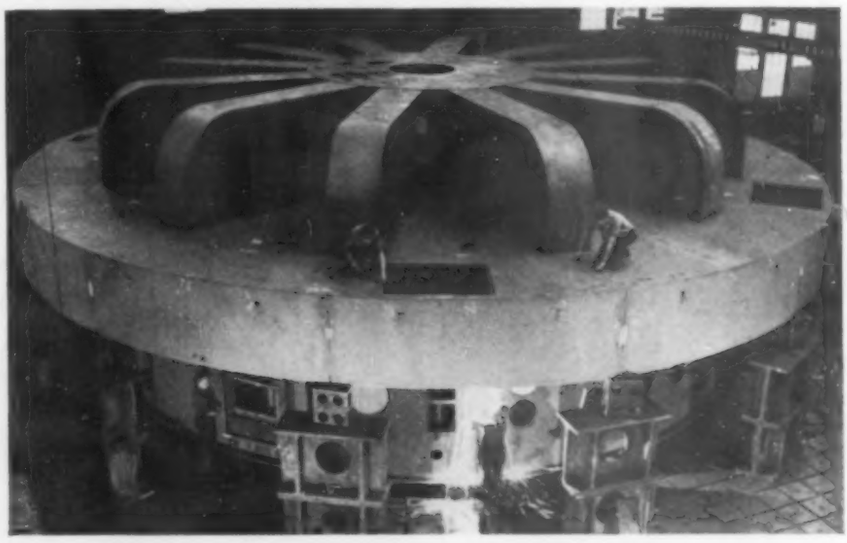


Fig. 4—Large Hydro-Electric Generator Fabricated by Arc Welding

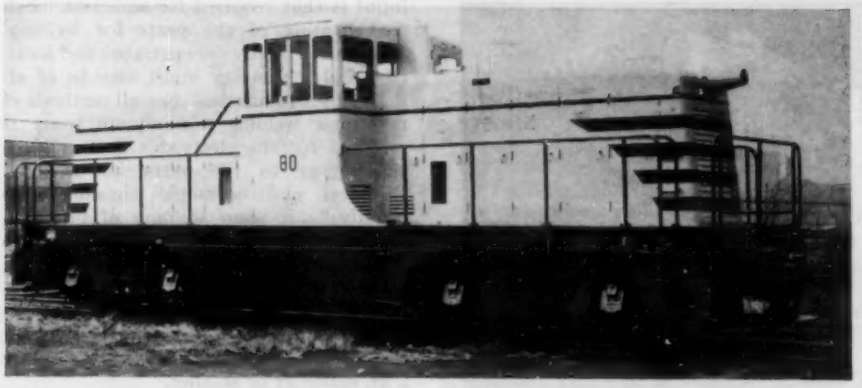


Fig. 5—Diesel Electric Locomotive of Welded Construction

Frequently subassemblies or component parts are made with one or all of these processes.

Adequate drawings are as important for welding as for other operations and as such are used for conveying to the fabricating shop information on exact welding requirements. It is recognized that there are many capable men in the shop thoroughly familiar with welding but they are not always in a position to know the engineering requirements. Drawings specify the location, type of weld, size of weld, length of weld, process to be used, tolerance required and any other pertinent welding instructions. Welds are specified in most cases by symbols or by reference to a cross section of the joint. Most design divisions establish mechanical design standards, depending on the type of apparatus, for welding the same as for other operations.

Fabricating

In the production welding of electric apparatus, machine arc welding is used to a large extent on repetitive applications and elsewhere when considered economical. Both heavily covered electrode and the submerged arc with bare electrode and flux are used. In most cases positioning or clamping equipment is required and used for machine welding applications. The chief advantages gained by machine welding are increased welding speed and improved appearance. Careful planning is necessary to avoid losing in set-up time the advantage gained by increased welding speeds. Machine arc welding, properly controlled, produces consistently high-quality welds.

Manual welding comprises by far the largest amount of arc and gas welding on electric apparatus. Most of the metal arc welding is with A.W.S.-A.S.T.M. E6010, E6011, E6013 and E6020 electrodes. Nearly all fabricating shops are equipped with a.-c. type welders for use with the latter three electrodes. Large diameter electrodes ($^1/_4$ in. diameter and larger) of the E6020 class are used with a.c. for manual welding and machine welding installations. Direct-current type welders, single operator and multiple operator, are used with E6010, E6013 and special electrodes for many special materials.

Most gas-welding operations are limited to single-tip type torches. Oxyacetylene is widely used; however, oxyhydrogen is often used for gas welding aluminum.

Resistance-welding machines are equipped with electronic control for accurate timing and regulation of the welding current. The large majority of resistance-welding equipment is of standard design and adaptable to a variety of applications. However, when production warrants, special machines designed for the specific application are used.

The use of resistance welding makes it possible to produce many types of electric apparatus of a lighter weight and better quality at a lower cost than by other methods. An important adjunct to the most effective and efficient use of resistance welding is the use of adequate and properly designed welding fixtures.

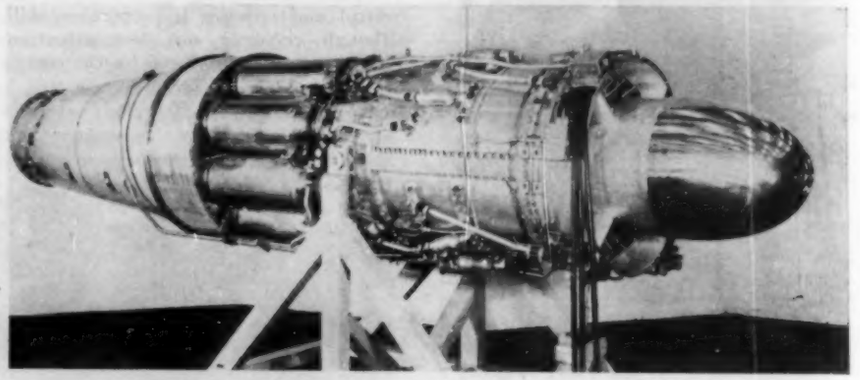


Fig. 7—Gas Turbine for Jet Propulsion of Airplanes Made of Welded Alloy Steel

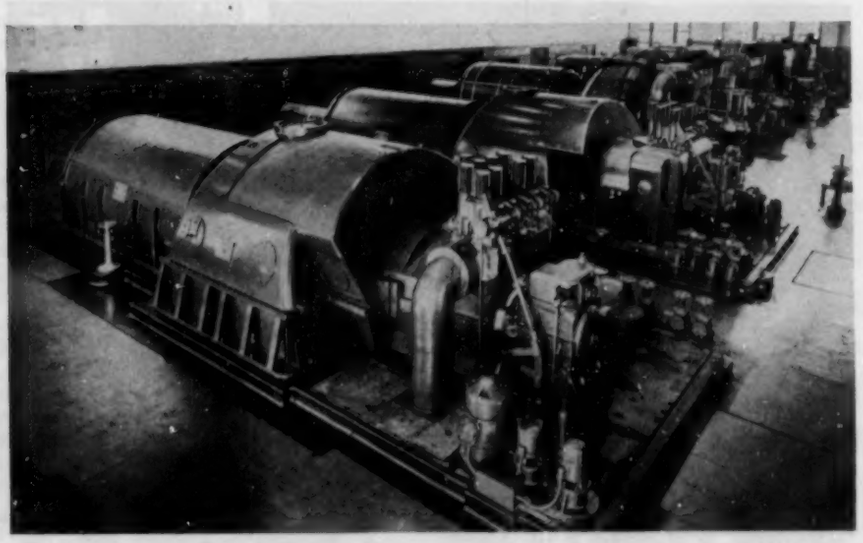


Fig. 6—Turbine-Generator Sets of Welded Construction

Transformers are an excellent example of where the three methods of welding are used. Power transformer tanks are entirely metal arc welded, whereas distribution transformer tanks, particularly the smaller units, are built by resistance welding. Subway type network transformers are fabricated exclusively by arc welding. The material is usually $^1/_4$ in. thickness or greater, to withstand corrosion, and does not lend itself to other types of welding for the types of joints involved. Cooling tube assemblies for power transformers, made up mostly of tubing 2 in. in diameter and under the material $^1/_8$ in. or less in thickness, are gas welded. The completed unit, depending upon the type, is either arc welded or bolted to the power transformer tank. Cooling tubes for some distribution transformers are made of formed material, $^1/_8$ in. in thickness or less and resistance seam welded to the tank casing. Core clamps and other parts of transformers are welded by arc welding or resistance welding depending mainly on the thickness of material and quantity involved.

Welding of transformers is characterized by the large number of linear feet of welding per pound of steel used, most of which must be pressure tight. In arc and gas welding, this is exemplified by the fact that where pressure-tight joints are required, the thickness of the material and structural requirements permit making most welds in a single layer or pass. With resistance welding this emphasizes the high degree of reliability which can be placed on welded joints. All other joints, with the exception of welds for sealing purposes against corrosion, are for structural purposes and must be 100% reliable.

Switchgear apparatus is often associated with transformers to form a unit substation. This type of apparatus is mostly metal arc and resistance welded. Like transformers, oil circuit breaker tanks must be oil tight and most welds are required to have minimum structural properties. Cubicles for housing circuit breakers and other switchgear equipment, control relays, etc., are made up of formed angle iron and plate construction and fabricated largely by resistance spot welding. Since these units are too bulky to take to a welding machine, portable spot welders are used and taken to the work.

Large motors and generators are mostly of heavy material and are fabricated by metal arc welding. Subassemblies, shields and ventilating parts lend themselves to fabrication by resistance-welding methods. Rotating parts and long straight sections are ideal for machine arc welding and manual welding with large diameter electrodes as the parts can be easily positioned. Component parts of frames, stiffeners, etc., which might normally be arc welded are resistance flash welded in cross sections up to 25 or 30 sq. in. The bases for motor and generators and motor generator sets are constructed entirely by arc welding principally of I-beam and other structural shapes.

The small amount of welding on small motors and generators is readily adaptable to resistance welding, although metal arc welding is used for the occasional joint not suited to resistance welding.

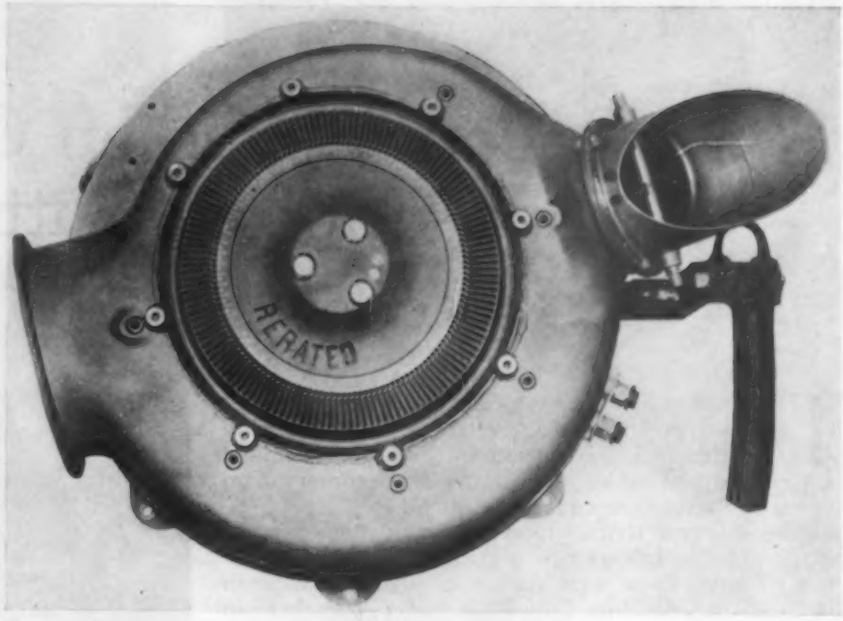


Fig. 8—Airplane Turbo-Supercharger of Welded Alloy Steel

Locomotives of the Diesel electric type have the trucks, pedestals, undercarriage, main frame and other heavy parts metal arc welded. Machine metal arc welding is used for welding I-beam sills to the bed plates. Cabs are constructed by spot welding with a gantry-type resistance welder.

Turbines consist mainly of three parts; a rotor with blading, a bottom half and a top half of a stationary element. Fabrication by welding presents a real challenge to welding as the materials used are made up largely of alloy steels. Materials are selected with due regard for pressures and temperatures involved. A search is constantly being made to find better materials, the majority of which to be useful in turbine construction must be welded without sacrificing their physical properties.

Metal arc welding is predominantly used on steam turbines. Gas welding is used for joining piping 2 in. in diameter and under. The use of resistance welding is, at present, limited but with suitable design it should be possible to extend the use of this process on many component parts.

On gas turbines about 40% of the welding is by the resistance method. The materials, mostly of high-alloy steel, are relatively thin and are ideally suited to resistance welding when properly designed. The remainder of the welding is done by several of the arc-welding processes depending, to some extent, upon the suitability of the process to each material. An increased amount of resistance welding will likely be used on some applications in the future.

There are many other types of electrical apparatus on which one or several welding processes play a prominent part but those mentioned seem to illustrate best where each process is normally applied.

Some Recent Canadian Contributions to Oxygen Cutting*

By R. A. Dunn†

THE technique of oxygen cutting in Canada has advanced greatly during recent years. Especially was this so during wartime when the great demand for war material broke down established conservatism and gave impetus to new methods and ideas.

While it is true that in most cases Canadian oxygen-cutting practice followed to a great extent that of the United States, there were numerous instances wherein new techniques developed simultaneously, or nearly so, in both countries. There were also times when new methods were employed in Canada far in advance of their adoption below the border. It is, however, hardly necessary among friends to argue the dates and times when one scooped the other.

In the production of a great deal of war material, Canada, of necessity, had to comply with United Kingdom specifications which naturally created many problems because of our different methods, equipment and techniques. It was not always easy to apply American reasoning to produce English goods—and get away with it! However, Canadians were generally quite successful in convincing tough United Kingdom Inspectors that many of their ideas had merit—even though subjected sometimes to amendments. Our combined resourcefulness, however, invariably surmounted most difficulties and added to our knowledge.

Early in the war, for example, one of our large ordnance plants found that they had a serious bottleneck in the production of the famous British 25-pounder field gun. The production of these powerful weapons was one of the Dominion's outstanding achievements, with the result that a great deal of attention was focused upon this particular problem.

Fig. 2—Scrap Removed from Recuperator Billet by Oxygen Machine Cutting

The main element of the recuperator assembly was normally pressed to shape after preliminary forging by means of a 2000-ton press, which procedure, however, still left a considerable amount of material to be removed. This, in the eyes of plant officials, consumed an unnecessary amount of time and labor and, therefore, oxygen cutting was suggested as a possible means of producing a unit closer to rough machining dimensions.

The suggestion was finally accepted with reservations—in particular, the cutting had to be performed above 1650° F. Due to the billets being of special alloy steel there was a strong feeling among plant inspectors that cutting at lower temperatures might be injurious.

At first oxygen cutting was tried on billets which had already been formed to rough shape by the large press. These were heated to approximately 1800° F. and then placed in position for oxygen cutting as shown in Fig. 1.

The standard technique which existed at that time for cutting the many contours in this 13 to 14-in. block just did not apply at the extremely high temperatures. After considerable trial and effort, success was finally achieved by using very low oxygen pressures—in the neighbor-

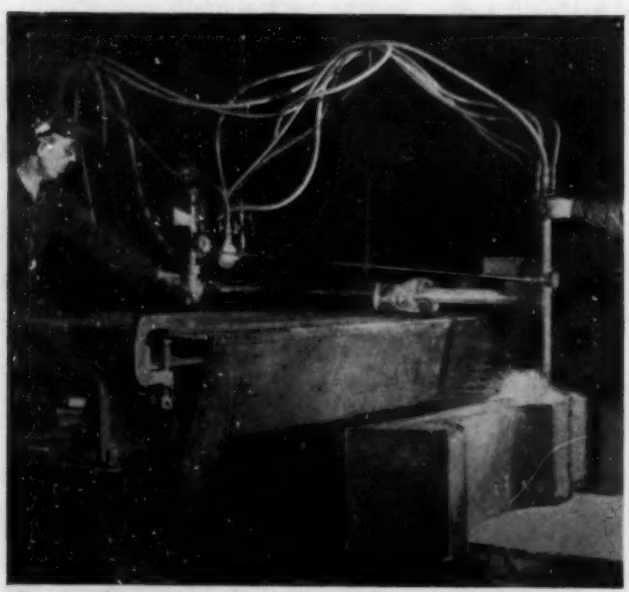


Fig. 1—Oxygen Machine Cutting 13-In. Forging for Recuperator Assembly of 25-Pounder Field Gun; This Operation Saved 50 Hours' Machining

* Scheduled for Twenty-Seventh Annual Meeting, A.W.S., Atlantic City, N. J., week of Nov. 17, 1946.

† Development and Engineering Dept., Canadian Liquid Air Co. Ltd., Montreal, P. Q.

Figs. 3 (Above) and 4 (Right)

These photos were taken during early stages when this method of shaping recuperator forgings was first introduced and setup necessarily of a temporary nature. Figure 3 shows a close-up of cutting operation and a portion of the cut; Fig. 4 clearly shows general shape of billet.

hood of 25 to 27 lb. That this step resulted in a large saving of machining time is evident by glancing at Fig. 2 which shows the scrap removed from the recuperator billet. Previously this had to be machined off.

Later on, the procedure was altered and the recuperator unit was cut directly from forged billets. The setup was also improved with the addition of large water-cooled torches and heat-resistant shields.

The low-pressure cutting techniques referred to above also developed in the States at approximately the same time although not on alloy steels at high temperature.

Mention should be made of the fact, however, that it was not long before the officials concerned were convinced that such high temperatures were an unnecessary difficulty with the result that tests established that 900–1000° preheat was ample to avoid the possibility of checks. This marked a great step forward in hot-cutting practice (Figs. 3 and 4).

A first also in Canada was the complete cutting of shell blanks from steel billets at room temperature with perfect uniformity in length. These steel billets were approximately 0.50% C and Canadian forging technique demanded that they be cut completely with a smooth uniform face rather than nicked and broken.

An early setup for this work is shown in Fig. 5. It consisted of a small cutting machine running on a track over a cutting table. Steel billets of normal length were laid on the table alongside one another and their ends kept in perfect alignment by means of a bar against which the ends were placed. Commencing at the end billet the

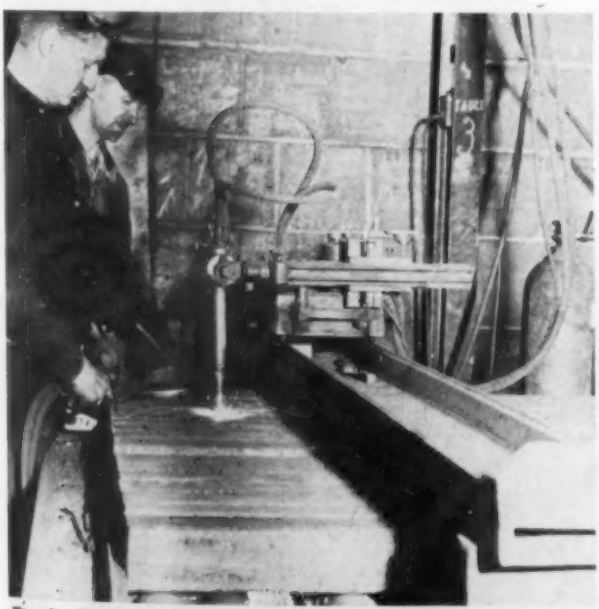


Fig. 5—Early Setup for This Work Consisted of a Small Cutting Machine Running on a Track Over a Cutting Table

Fig. 6—A Sea of Oxygen-Cut Billets Waiting to Be Picked Up

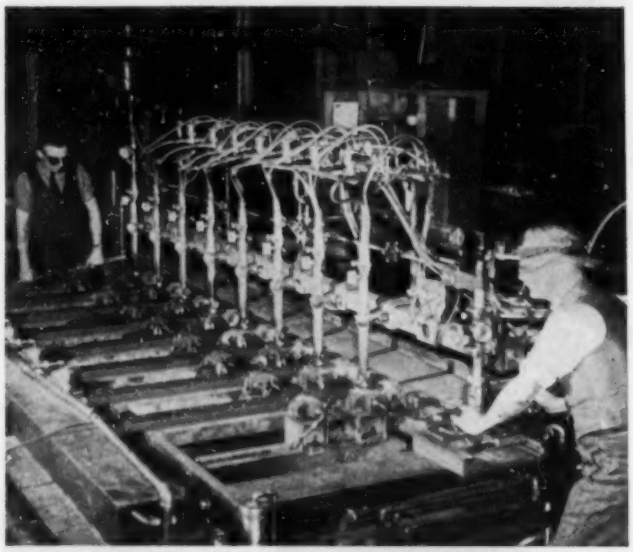


Fig. 7—Eight-Torch Oxyacetylene Cutting Machine

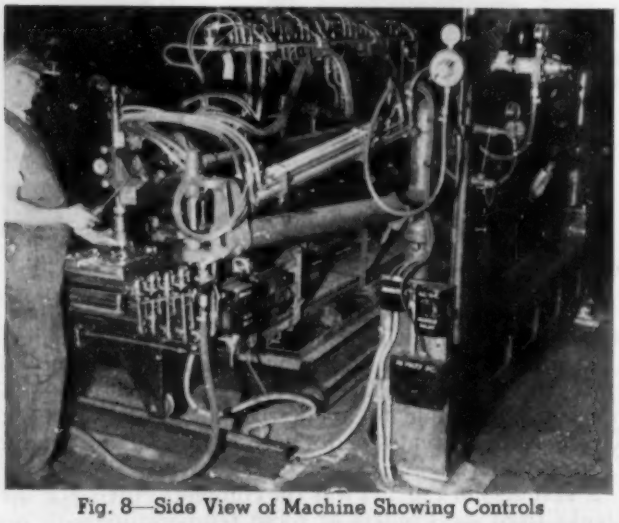


Fig. 8—Side View of Machine Showing Controls

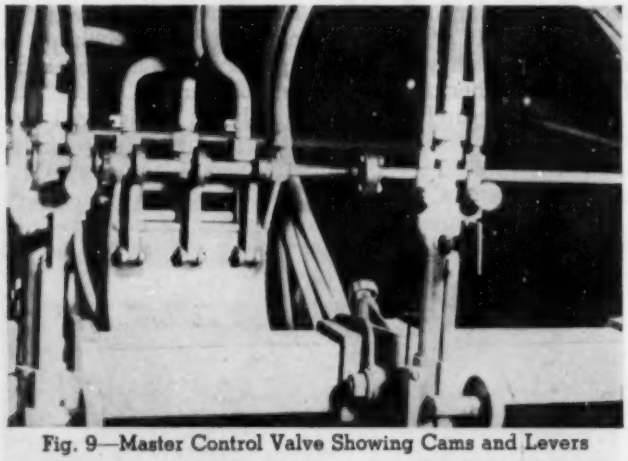


Fig. 9—Master Control Valve Showing Cams and Levers

metal was preheated and the oxygen jet turned on which started the cut. The cutting machine moved under its own power and severed the billet; meanwhile the operator, with a hand torch, was heating the edge of the next billet so that when one billet was cut no time was lost for the metal to heat up before the cut began on the next one; in this way the operation was made continuous until all the billets had been cut. The blanks were removed continuously and the fresh billets moved down so that when the machine reached the end of the bed it was merely reversed to cut back across the table (Fig. 6).

Actually there were no new revolutionary cutting techniques developed for this work but the consistency and rapidity with which all these operations were performed was astonishing and the number turned out per day ran into tens of thousands. Later on, the cutting setups were improved and made a little more elaborate so as to result in higher productions.

Another application of oxygen cutting pioneered in Canada was the use of the process on the production of Bren Machine Guns and Browning Automatic Pistols.

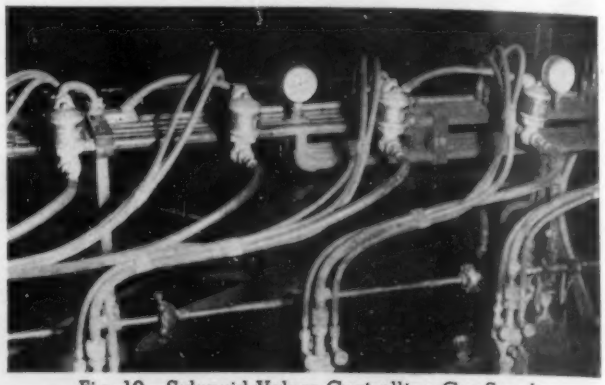


Fig. 10—Solenoid Valves Controlling Gas Supply

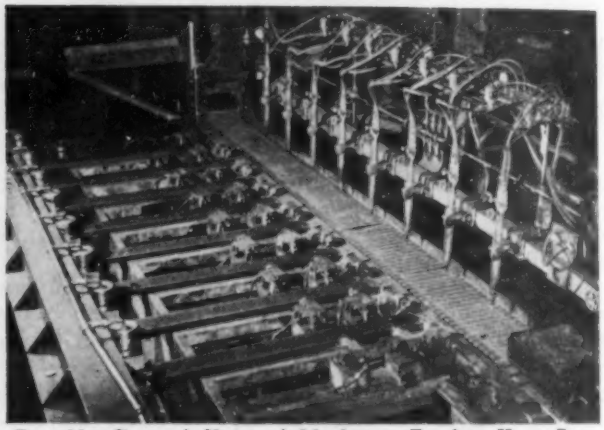


Fig. 11—General View of Machine; Torches Have Been Moved Away from Cutting Positions to Show Rams, Carriage and Conveyor

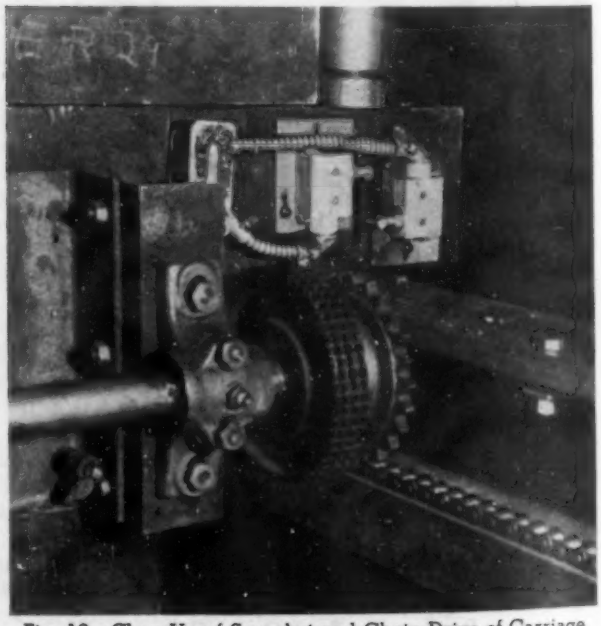


Fig. 12—Close-Up of Sprocket and Chain Drive of Carriage

Bren gun bodies and Browning pistol receivers and parts were oxygen cut at a considerable saving compared to forging. Although no new oxygen-cutting technique was involved, still the application can be considered an innovation in the cutting field.

It was in connection with a very large order from the Chinese Army for a new type automatic pistol that oxygen cutting was investigated on a mass production basis as a possibility of speeding up the initial shaping operations on the main parts of the pistol. A completely automatic setup was envisioned comprising a suitable oxygen-cutting machine and equipment for locating and feeding stock to the cutting torches and for removing the parts after cutting them preparatory to machining.

The central unit around which the ingenious mechanism was constructed was an Oxygraph oxygen-cutting machine equipped with eight torches. This machine, of the pantograph type, was capable of multitorch operation and was used with a magnetic tracer. Cutting speeds which were recorded on a tachometer were available at will by merely turning the index speed control to the desired speed.

All controls were centralized on a unit called the Control Head Assembly, from which point the preheating oxygen and acetylene and cutting oxygen could be turned

Fig. 13—Spring-Loaded End Rams

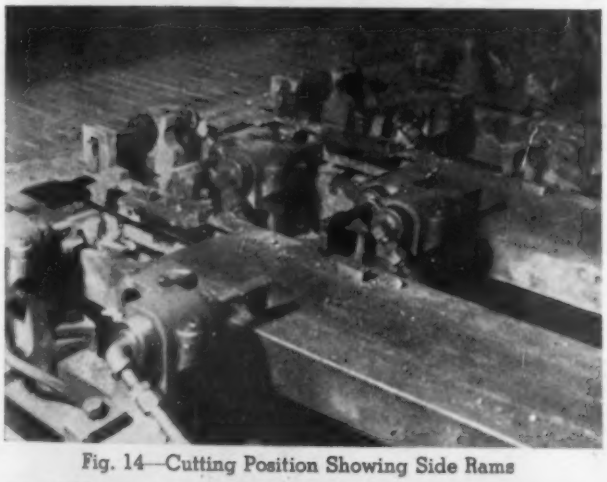


Fig. 14—Cutting Position Showing Side Rams

Fig. 15—Cutting Position with Stock in Place (Note Locating Holes for Torches)

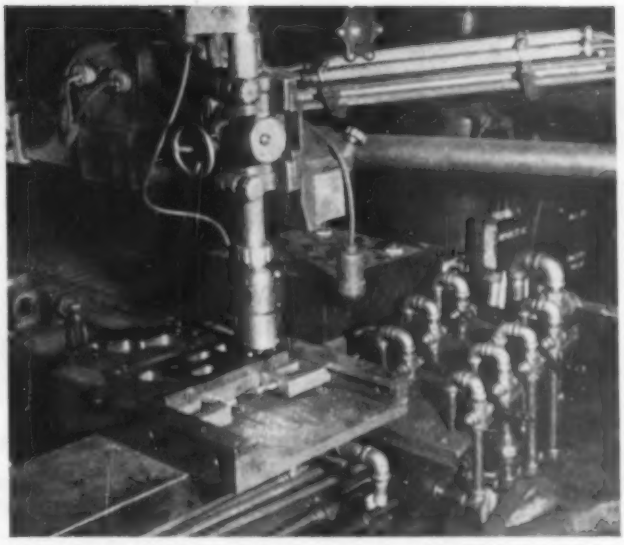


Fig. 16—Magnetic Tracer, Templates and (Right) Valves for Rams

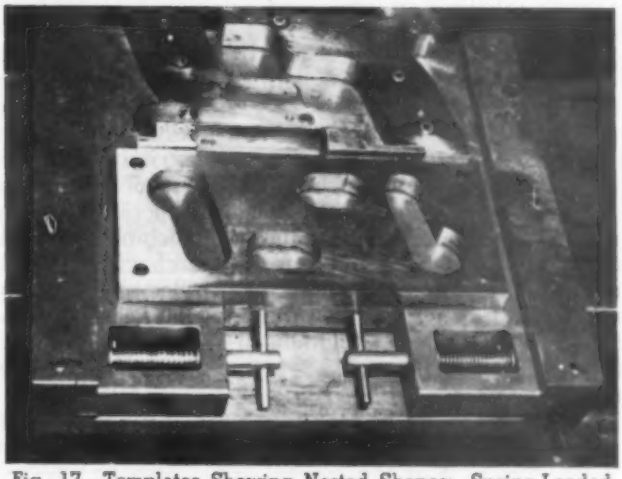


Fig. 17—Templates Showing Nested Shapes; Spring-Loaded Dowels Are in Foreground

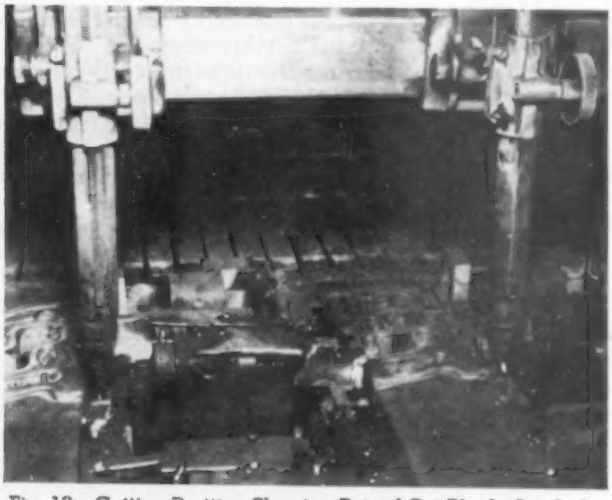
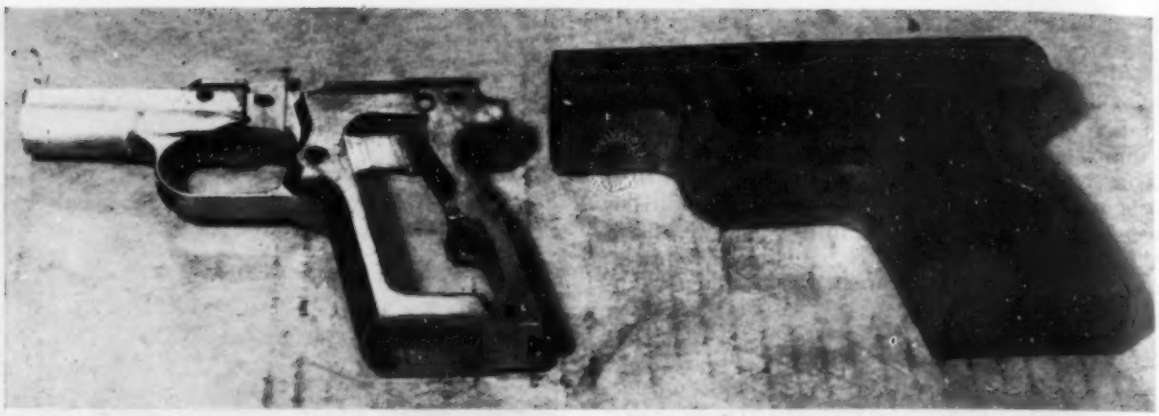


Fig. 18—Cutting Position Showing Pair of Cut Blanks Ready for Removal



Figs. 19 and 20—Pistol Blank Before Machining and After Machining

on or off by means of a special master control valve. This valve was operated by remote control from the Control Head Assembly by a system of cams connected to extension rods fitted with hand wheels. By this means oxygen and acetylene were supplied to the torches, and city gas to the automatic pilot light, thus providing for simultaneous lighting of all torches.

For use on this particular job, the valve lever controlling the cutting oxygen was permanently depressed by a metal strap so that the flow of gas to each torch could be controlled by solenoid valves. These were located at the cutting oxygen outlet of the gas distribution header and allowed the cutting oxygen to be cut off at any one of the eight torches should it cease to function properly during operation. In this manner the machine could still be kept producing while the defective torch was being adjusted. The solenoid valves were controlled by individual switches, but a master switch wired in series with the machine motor switch put them all in operation simultaneously with the starting of the tracing motor and the flow of cutting oxygen.

The torches could be raised or lowered by means of a hand wheel attached to the Control Head Assembly, but complete control of the torches could also be effected at the torch positions. These various features are illustrated in Figs. 7–10. It will be evident from this brief description that the Oxygraph admirably filled the initial requirements for a "suitable cutting machine," while its shape and design made easier the problem of devising the mechanical arrangement for handling the stock.

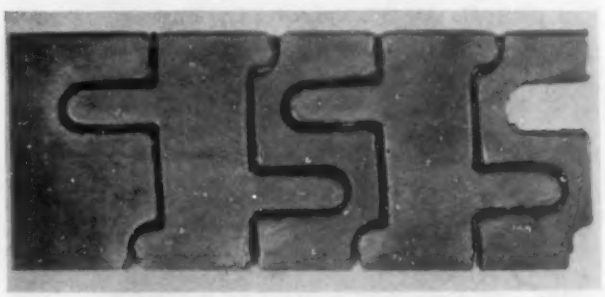
The main part of the equipment for this latter work consisted of a rectangular steel carriage extending the full length of the machine and supported on precision ground wheels fitted with roller bearings which allowed the carriage to move smoothly backwards and forwards on tracks; a chain and sprocket drive providing the motive power for these movements (Figs. 11 and 12).

On the upper part of the carriage were mounted eight sets of air-operated rams (one set for each torch position), for locating, feeding and holding the steel to be cut. The pair of rams at each torch position were arranged to exert their pressure laterally against the sides of the steel stock, their purpose being twofold: to clamp the steel in place while cutting was taking place and also to counteract any slight variation in width of stock as well as contraction and expansion. Two views of these rams, with and without stock in place, are seen in Figs. 14 and 15.

Another ram, which was spring-loaded was located on a fixed support at the opposite end from the cutting position of each torch and exerted its pressure longitudinally (Fig. 13). This ram pressed against the end of the stock being cut and at the same time (because of the spring) took care of any slight variation that might occur in stock length. Valves for controlling the rams were conveniently located near the main Control Head Assembly of the machine (Fig. 16).

When the machine was set up to cut pistol blanks, eight bars of steel, $54^{5}/_{8} \times 4^{5}/_{16} \times 1^{1}/_{8}$ in., were placed on the carriage and positioned by the rams. The torches were then lined up with the starting holes, drilled in the stock (indicated in the pictures), for the cutting operation.

Fully automatic cutting was performed by means of the magnetic tracer in conjunction with two steel templates (Fig. 17), These were mounted on a small platform attached to the carriage. Each template was so designed that two identical shapes were nested (inside and outside profiles of pistol) thus enabling sixteen parts instead of eight to be produced at one setting of the ma-



(a) Top Surface of Bar Showing Waste Portion (on Left-Hand End) and Component Held in Place by "Slag"

(b) Under Surface of Same Bar

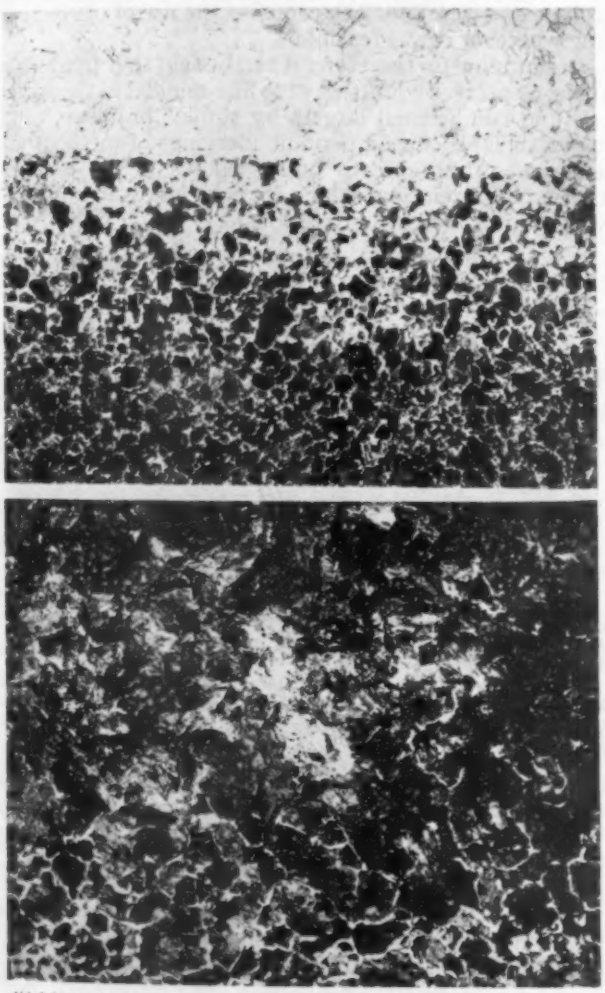
(c) Side View of Bar

Fig. 21

chine. The inside shapes were cut first then the operator released two spring-loaded dowels holding the templates and slid them back to place the outside shapes in position for the second cutting. Adjusting the magnetic tracer to the template simultaneously caused the torches to be positioned over the proper place on the stock and the cutting continued. A close-up of a cutting position showing a pair of cut blanks is shown in Fig. 18.

After the first sixteen blanks were cut, the lateral or side rams were released; the carriage was then set in motion, which caused the fixed longitudinal rams (pressing against the end of the stock) to push the uncut portion of the steel bars into place at the cutting position for the next series of cuts. As the carriage moved back each new position was accurately determined by means of a spring-loaded stop or pin which engaged the proper hole on guide bars located on the fixed side frame of the machine. This was repeated until the stock was used up.

(*a*) Microstructure at 75 × of a Cross Section Through Surface of a Bar of Unsatisfactory Characteristics



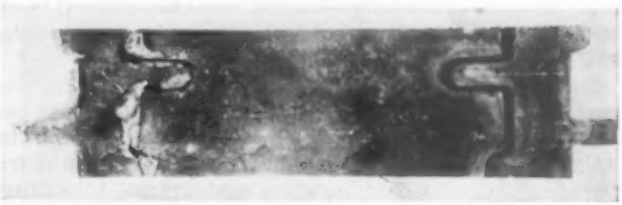
(*b*) Microstructure at 75 × of a Cross Section Through Surface of a Bar of Satisfactory Properties

Fig. 22

At the same time as the carriage was moving to the new position, the parts previously cut were automatically pushed on to a conveyor which is part of the carriage assembly and mounted flush with the cutting position. The conveyor was set in motion and carried the blanks away from the cutting positions into a box. The blanks were then ready for the machining operations (Figs. 19 and 20).

If by accident any of the torches were bumped out of alignment a quick and accurate method of checking alignment was provided. A hole of the diameter of the magnetic tracer roller was located on the template and a corresponding hole was correctly located on the front end of the work support jig for each of the torch tips. If tips located accurately on the holes, then the torches were properly aligned; if not, adjustment could be made to the torch which happened to be out.

(*a*) This Shows Absence of "Slag" Adherence on Component Cut from Right-Hand End of Bar with Ground Surface on Underside of Bar



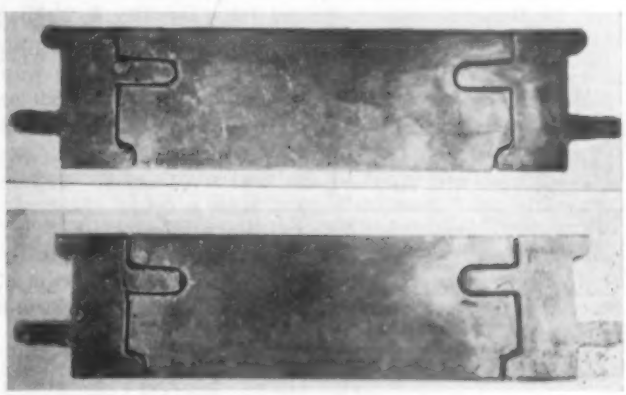
(*b*) The Typical "Slag" Adherence on Underground Surface of Same Bar as Above Is Shown on Component on Left-Hand Side, Flame Cut with the "Hot-Rolled" Surface on Underside of Bar

Fig. 23

Although originally designed particularly for the production of pistols it was found that, by carrying out certain minor adjustments, this setup could be just as successfully adapted to the shaping of Bren gun bodies on a mass production basis, to which purpose it was fully employed.

It was in connection with this application that an important discovery was made. When production cutting was started on one of the small components of the Browning pistols it was found that some of the cut pieces would not drop off clean. In fact most pieces were to all intents and purposes, fused together at the bottom of the kerf by a tough resistant iron slag.

Fortunately the trouble was encountered during the tool-proving stage of the machine and consequently time could be taken to investigate the question in the Company's metallurgical laboratory. The problem was really



Figs. 24 (*a*) and (*b*)—Illustrating Desirable Conditions Obtained in Flame Cutting a Carburized Bar

After cutting a component from one end the bar was turned over and cut on the opposite side in order to check both surfaces on the one sample piece.

serious because apart from the fact that the attached slag was extremely difficult to remove, the machine would not operate automatically unless the waste pieces fell of clean.

Figure 21 (*a*), (*b*), and (*c*) shows some of the components cut from the bar stock and held rigidly to it by slag. This bar stock was $^5/_8$ x $2^1/_4$ in. and was purchased to a chemical specification equivalent to S.A.E. 1075. It was supplied in a hot-rolled annealed condition.

Many steps were tried in an attempt to overcome this disagreeable condition. Cutting-oxygen pressures and orifice sizes were varied within wide limits without appreciable results. Excessive slagging was encountered in all cases with the exception that higher pressures and smaller orifices seemed to produce better components.

In addition the preheat flames, torch positions and speed of cutting were varied. Even descaling of the bar and the use of antiweld coatings were tried. As might be expected, heavier preheat and slower speeds had a detrimental effect whereas descaling and antiweld coatings made no change.

It was soon noticed that even under similar conditions some bars would cut clearly whereas others would slag excessively. This prompted a closer investigation of the bar stock material and samples were consequently cut, machined and polished for a microscopic examination.

The microstructure of bars of unsatisfactory properties disclosed deep decarburization on the surfaces. Figure 22 (*a*) shows one such bar with complete decarburization extending to a depth of 0.012 in. Bars of satisfactory properties on the other hand, did not show such complete decarburization on the surface but only a light partial decarburization (Fig. 22 (*b*)).

That this complete decarburization of the surface was the root of the trouble was quickly established. A bar of unsatisfactory properties was selected and sample cuts were made on it in the (*a*) as-received condition, (*b*) after surface grinding the under side to remove decarburization and (*c*) after carburizing at 1650° F. to a depth of 0.015 in.

Cuts made in the as-received condition showed the same ill effects whereas cuts made after grinding the surface or carburizing completely eliminated the trouble. Further studies confirmed that where the complete decarburization extended beyond 0.006 in. then the resulting slag would remain in the kerf behind the cut and freeze the waste piece to the parent metal.

Figures 23 (*a*), (*b*) and 24 (*a*), (*b*) show the results of some sample cuts made on bars of unsatisfactory properties in the as-received condition and after undergoing the various treatments mentioned.

In view of these studies the future specifications to which the raw material was ordered included a clause which limited the maximum depth of decarburization, while the excessively decarburized material already purchased was production carburized which allowed it to be processed without any further difficulty.

Many other Canadian contributions to oxygen cutting could be mentioned. It is felt, however, that the few examples given in this paper clearly indicate that Canadian technicians were quick to promote the use of oxygen cutting wherever it was feasible.

In summing up therefore, it can be said that technicians in our respective countries were like-minded in these matters and conditioned largely by similar problems which sooner or later caused periodic mergings of methods and techniques profitable to both—thanks to the excellent international relations which we both enjoy and of which we should be increasingly jealous.

Acknowledgments

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(*Continued from page 935*)

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Ships, Maintenance and Repair. Some Wartime Examples of

(*Continued on page 974*)

Tool and Die Welding*

By A. R. Butler† and F. E. Kessler†

Importance to Industry

TOOL steel welding is a specialized phase of welding that has increasingly come to the front in importance to the metal working industry. It may be defined as the deposition by the metallic-arc, atomic-hydrogen or oxyacetylene processes of the basic types of tool steels such as water hardening, oil hardening, air hardening and hot working. The weld deposits have characteristics typical of the tool steels in their various classifications. Each welding process offers its own particular advantages, but the metallic-arc method will probably prove to be the most widely used. Therefore, the balance of this paper, with the exception of the treatise on repairing high-speed steel cutting tools by the oxyacetylene welding method will be devoted to the metallic-arc welding method.

The arc welding of tool steel is actually a hardening process. The coated electrodes utilized are in an annealed state, and the weld metal is hardened by air quenching from the high heat of the arc. The weld deposits are "hard-as-welded" no matter whether they are applied to hardened or annealed tool steel, or to mild, medium, high-carbon or other alloyed steel. The weld deposits of tool steel electrodes can be annealed, in order to facilitate machining, and afterwards heat treated and tempered. Therefore, tool steel welding should not be confused with the practice commonly known as hard facing, which has a different field of application. Hard facing materials will not, as a rule, respond to heat treatment because of their high alloy content, which results in unchanging and unvarying hardness.

Tool steel welding can be used profitably in any plant using tools and dies. It will save many man-hours, conserve material and minimize production delays.

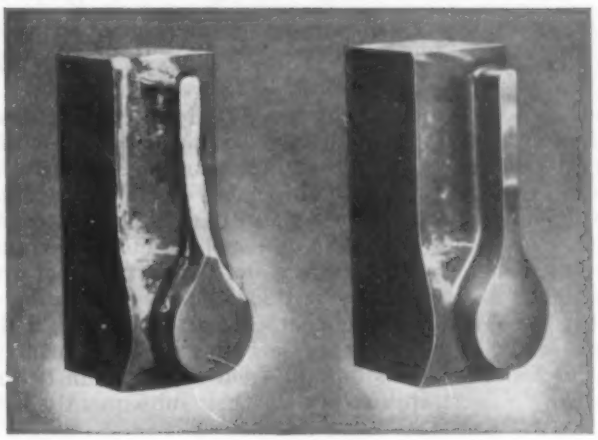
Virtually all types of tool steels can be welded by the metallic-arc method. Die units used for blanking, forming, forging, drawing, embossing, coining, hot and cold trimming, etc., can be salvaged or reclaimed. Damaged or discarded tools can be reworked. In addition, die units can be compositely fabricated by welding.

Tool steel welding affects savings in time and material; keeps equipment in service longer; makes replacements less frequent; eliminates in many cases the need for keeping duplicate die sections; reduces interruptions in production and the planning necessary on new die construction; cuts down time needed for "change-over."

Tool and die welding can be separated into four distinct phases:

1. Repairing dies.
2. Compositely fabricating dies.
3. Correcting designs.
4. Rectifying errors.

To stress the importance of these to industry, each phase will be discussed separately.



No Heat Treatment Was Required for the Repair of This Oil-Hardening Die

Repairing Tools and Dies

Existing units that fail in operation can be welded, either partially or wholly, resulting in a minimum of "down-time." The confining of repairs to immediate faulty areas reduces expense incidental to "spotting-in" and regrinding or "barbering" over entire working areas. Dimensions are retained within close limits and the use of inserts is eliminated. Valuable heat-treating time is saved as weld deposits of tool steel welding electrodes are "hard-as-welded." In most cases subsequent heat treatment, other than tempering, is not necessary if the units lend themselves to grinding.

Plant efficiency is increased by the utilization of tool and die welding. Welding makes possible less frequent replacements of die units, which result in labor saving and reduce production interruptions. Because of fewer replacements of units, with incidental labor expense, the operating efficiency of a plant is much higher, because of uninterrupted production. Less planning is required on new die construction and die maintenance. Sustained operation of units made possible by welding, eliminates in many cases the necessity of maintaining duplicate die units. Two, three or even four types of tool steel electrodes can be applied on one die unit, eliminating the use of inserts which sometimes are impractical or unsatisfactory on large units and impractical on small ones. This permits one die unit to perform various functions, which would ordinarily require separate die units and separate operations. The practice of reclaiming or repairing tools and dies by welding results in longer life of plant equipment. Welding also permits changes in design of units during die "try-out" or die "change-over."

Compositely Fabricating Tools and Dies

When practical, units can be compositely fabricated by utilizing a mild, medium, high-carbon or a low-alloyed

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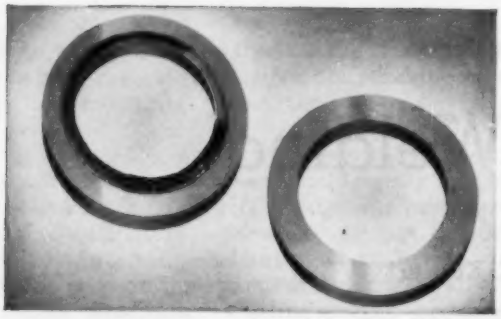
† President and Field Engineer, respectively, Welding Equipment & Supply Co., Detroit, Mich.



Composite Fabrication of a Draw Ring. The Base Is Mild Steel, and Deposits of Tool-Steel Electrodes Constitute the Working Edge. The Two Views Show the Unit as Prepared and As-Welded and Partially Finished. No Heat Treatment Was Given; the Ring Was Ground to Size and Put to Work

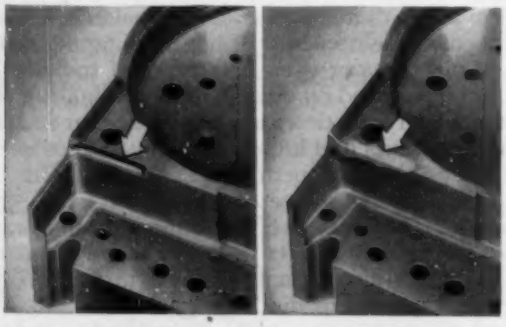
steel as a base and welding the cutting edges or working areas with tool steel electrodes having the desired tool steel characteristics. The ability to produce a composite tool or die, not otherwise obtainable except by welding, results in a working surface of any desired characteristic, with a resilient core. This prolongs the life of die units and avoids costly maintenance and the curtailing of production. Advantages realized include the elimination of subsequent heat treatment, other than tempering, if the units lend themselves to grinding; permit finish machining as last operations; or the weld deposits can be annealed, to facilitate machining, then subsequently heat treated.

Many tools and dies are susceptible to breaking because of their inherent hardness. A resilient core secured through composite fabrication reduces this susceptibility, thereby prolonging the life of the units. Thus, costly maintenance and the curtailing of production are avoided.

In composite fabricating by welding it is very beneficial that the finish machining, drilling, etc., can be done as final operations.

The use of inserts is eliminated in composite fabrication by welding. The practice of using inserts on die units is sometimes too costly, unsatisfactory or impractical as, unlike welds, they never become integral parts of the die units. In a great many cases, small die units do not lend themselves to insert usage.

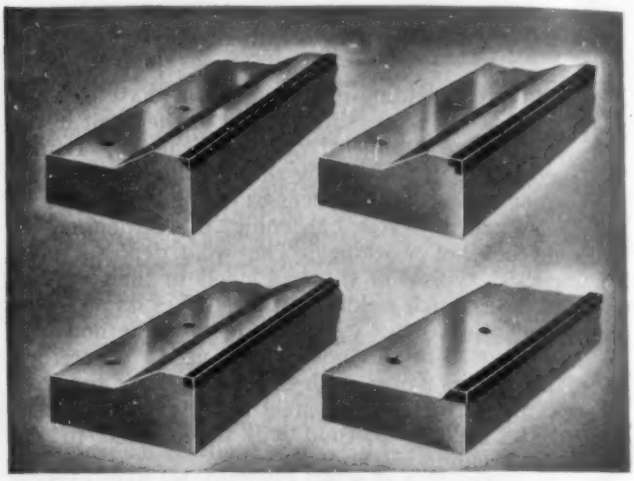
Sometimes it is impractical or impossible to construct a die out of one type of tool steel if the die must perform individual functions, such as one that must "trim," "form" and "spank or restrike." It is impossible to secure composite tool steel in one unit, with the qualities necessary to perform each of these operations. Therefore, it is very beneficial that this accomplishment can be made by welding, on the cutting or working areas, depositions having the desired characteristics to perform each individual operation.



This Plastic Mold Die Is a Fine Example of the Manner in Which Tool-Steel Welding May Be Used to Make Changes in Contours, Corners or Edges in Order to Correct Designs During Die Tryout or Changeover Periods

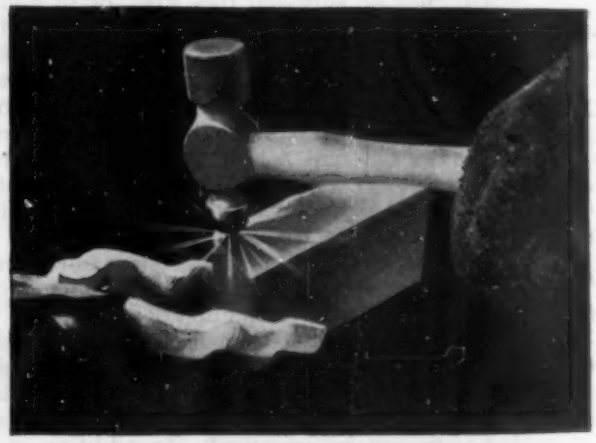
Correcting Design

Welding facilitates making changes in contours, corners or edges of tools and dies to correct design during die "try-outs," or die "change-over." In a great many cases, original die units, under the stress of the work that they are performing, will not stand up. The entire cutting or working area may be affected or sometimes partially affected. Tool steel welding will permit the addition of requisite surfaces at desired points—thereby reducing the possibility of subsequent failure and necessary replacement.



Composite Fabrication

Types of preparation for cutting or forming edges: Upper left, angle type; upper right, 90° shelf type; lower left, straight shelf type; lower right, self-created land type.



Peening Tool Steel Weld Deposits

Rectifying Errors

In the manufacturing of tools and dies, welding permits the correction of errors and in some cases replaces conventional inserting methods.

Background Knowledge Required

Manufacturers of tool and die welding electrodes furnish technical information pertaining to their products and their uses. However, there is other knowledge that can be acquired by those engaged in tool and die welding that will prove to be very helpful.

Some knowledge of the basic mechanical principles and fundamental operating details of tools and dies should be acquired.

Oil-Hardening Punch Repaired with Oil-Hardening Tool Steel Electrodes. Worn Down; As-Welded; As Finished.

It would be helpful for those engaged in tool and die welding to accumulate details in connection with alloying elements in steel. Tool steels are carbon steels to which have been added alloys, in varying quantities, to give them certain special characteristics. Such elements as carbon, manganese, silicon, chromium, nickel, tungsten, vanadium, molybdenum and cobalt are induced into steel to meet extra requirements such as production of greater wear resistance and hardness; to produce greater toughness or strength; to stabilize size and shape during changes of heat and cold; to impart "red hardness" to the steel so that it will remain hard while red hot.

Because of the diversified composition of tool steels, the heat treating of same is a vast and complex subject. For the purpose of learning about tool steel welding it is not necessary that the subject be delved into to any great degree. However, the fundamentals of heat treating are important and will be of extreme help to those engaged in tool and die welding. It has been determined that, in practical tool and die welding, it is not necessary that the electrode used be the exact match to the analysis of the tool steel being welded. However, in most cases, the welding electrode used should match the heat treatment in its classification as closely as possible. Therefore, knowledge of the basic principles and facts in connection with heat treatment will be helpful. Such terms as "annealing," "normalizing," "hardening," "tempering" should be thoroughly understood.

Knowledge of the methods of hardness testing is beneficial. Information pertaining to the "file test," the "Scleroscope," the Rockwell Tester and Brinell Tester can be easily secured.

It is beneficial to have some knowledge of the types and brands of tool steel on the market, their trade names, characteristics and recommended heat treatment. This information can be secured through directories that are currently being published. Knowledge of the analyses of the tool steels is the first step to be taken in order to get acquainted with their properties and characteristics.

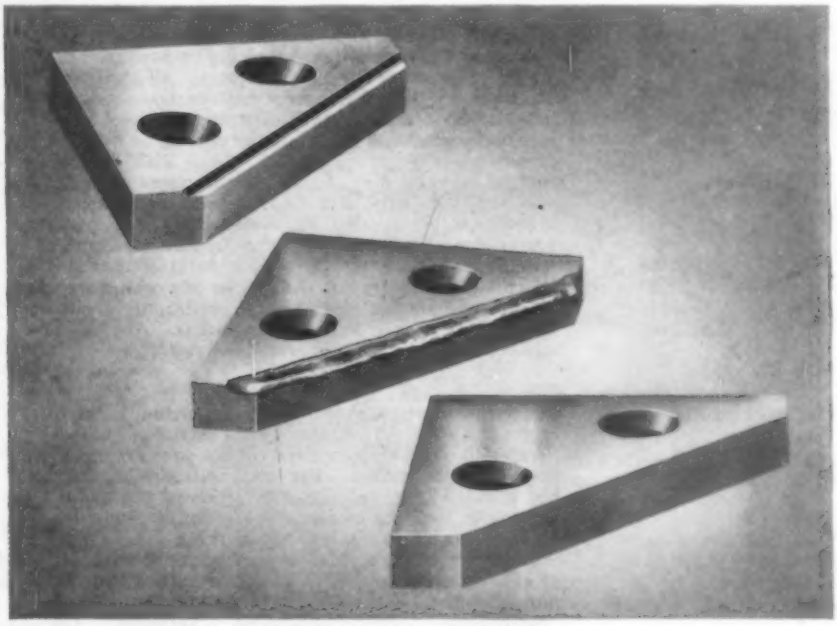
All manufacturers of tool steels specify the analyses of their various grades. There are literally thousands of different brands of tool steels on the market resulting in a great many variations in analyses and recommended heat treatments. For the purpose of simplifying the arc welding of tool steels, four general classes of welding electrodes, with the exception of high-speed steel electrodes, can generally be utilized. It can readily be realized that it would be impossible and impractical to have a tool steel welding electrode matching each and every analysis or exact heat treatment of the hundreds of brands on the market. In spite of the many different trade names of tool steel there are only four classifications in so far as welding is concerned: Water hardening tool steel; oil hardening tool steel; air hardening tool steel; and hot working tool steel. While there might be wide variations in analyses of tool steels the basic heat treatments, in their classification, are similar. Therefore, in welding it is not a question of matching the *analysis* of the steel, but of matching the heat treatment in its classification as closely as possible.

Products and Procedure for Repairing and Compositely Fabricating Tools and Dies

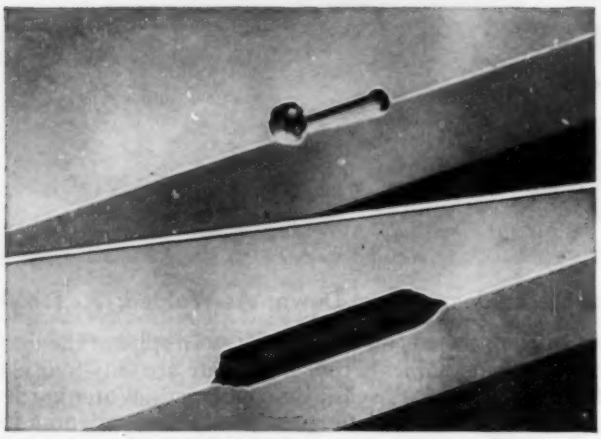
Tool and Die Welding Electrodes

Tool and die welding electrodes on the market can be divided into two distinct categories. In the first group are the basic tool steel welding electrodes such as water hardening, oil hardening, air hardening, including H.S.S., and hot working. These are alloyed with various elements and are ferrous in character. The second group are classified as alloy welding electrodes used on cast drawing and forming dies as well as on forging dies. As a general rule, weld deposits with tool steel welding electrodes will respond to the heat treatment recommended for the average tool steel in its classification.

The alloy welding electrodes used for tool and die repair are varied in nature. The pure nickel, copper-nickel



Water-Hardening Shear Blade Which Could Not Withstand the Severe Working Condition to Which It Was Subjected. The Cutting Edge Was Completely Faced with Oil-Hardening Electrodes, Increasing the Life per Regrind from Two to Five Weeks



Preparation for Partial Repair

and Monel electrodes are generally used as a foundation on cast structured units preparatory to facing with other alloy electrodes of the chromium-nickel variety. Alloy welding electrodes which are used for tool and die welding, because of their high-alloy content, will not respond to any heat treatment and hardening is effected only through the work hardening of the depositions.

Hardness developed in weld deposits of tool steel welding electrodes will vary according to the following principle factors:

(*a*) Pretreatment—such as the preheating temperature employed.
(*b*) The technique employed during the welding sequence.
(*c*) Admixture of the base metal with the deposit, which will influence the hardness "as-welded," or when heat treated.
(*d*) The rate of cooling, as the object being welded acts as an indirect cooling or quenching medium.
(*e*) The tempering degree employed after welding.

Tool and die welding electrodes on the market are of the coated variety. Some of these are simply coated with deoxidizing agents while others have mineral alloyed coatings. Both of these are conducive to proper arc action and form a protective slag over weld deposits. This aids in keeping the weld deposits free from porosity and slag inclusions. Mineral alloyed coatings on tool steel electrodes are desirable as they insure the incorporation of the required alloys in the weld deposits. Certain percentage of lost alloying elements occurs during welding operations and these lost alloying elements can be compensated for by incorporating same within the coating on the welding electrodes themselves.

Table 1 can be used for determining recommended uses for and the properties of the welds produced with tool and die welding electrodes.

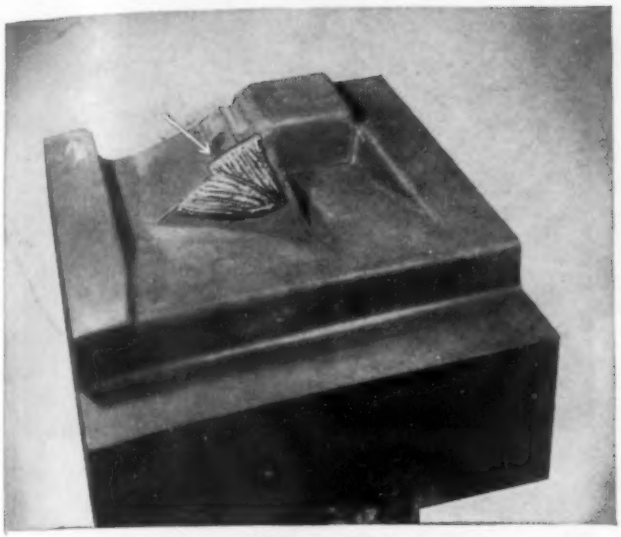
Tool and Die Welding Procedure

Repairing Existing Die Units (*Recommended Welding Sequence*).—The importance of proper welding sequence and procedures cannot be stressed too forcibly. Best results depend not only on the choice of the right tool steel electrode but on using it in the proper manner and following the correct welding sequence. Following are the main steps in correct welding sequence:

1. Determining the type of steel to be welded
2. Selecting the proper electrode.
3. Preparing the surface to be welded.
4. Preheating.

Table 1

Electrodes	For Welding and Repairing	Properties of Welds Produced
Water-hardening tool steel electrodes	Damaged or worn tools and dies in the water-hardening class. Also for compositely fabricating water-hardening units, using a mild or medium carbon steel as a base	Typical water-hardening tool steel deposits are "hard-as-welded," can be heat treated. Approximate hardness 56–60 Rockwell C
Oil-hardening tool steel electrodes	All types of tools and dies in the oil-hardening class—especially those of the "manganese," "tungsten" or "chromium" types of nondeforming or nonshrinking steels. For compositely fabricating oil-hardening units using a mild, medium or high-carbon steel as a base. Also for converting existing tool steel units into composite ones by facing the cutting or working areas	Typical oil-hardening, nonshrinking tool steel deposits having excellent grain structure and cutting qualities, withstanding extreme shock. "Hard-as-welded" deposits can be heat treated; approximate hardness 56–60 Rockwell C
Air-hardening tool steel electrodes	Damaged or worn dies of the 5% chromium varieties and also the "air" and "oil" quench high-carbon, high-chromium types. For compositely fabricating units using a medium high-carbon or S.A.E. steel as a base. Also for converting existing tool steel units into composite ones by facing the cutting or working areas	Typical air-hardening, 5% chromium, nondeforming deposits which are "hard-as-welded"; can be heat treated; approximate hardness 60–62 Rockwell C
High-speed steel electrodes	Principally where high steel characteristics are desired on cutting edges or over working areas. *Not recommended for repairing high-speed steel cutting tools*	Typical molybdenum high-speed steel deposits which are "hard-as-welded." Excellent cutting qualities in combination with desirable toughness. Can be heat treated; approximate hardness 60–64 Rockwell C
Hot-working tool steel electrodes	Damaged or worn "chromium," "tungsten," "high-carbon chromium," "chromium-tungsten" or "molybdenum" hot-working dies used in hot-working metallics and nonmetallics. For compositely fabricating hot-working units using S.A.E. steels of the nickel-chromium varieties as a base. For converting existing cold-working units into hot-working ones	Typical chromium-molybdenum-tungsten hot-working tool steel deposits which are "hard-as-welded"; can be heat treated, approximate hardness 50–54 Rockwell C
High chrome-nickel alloy	Deformed, broken or spalled areas on hot or cold forging of the carbon types of "chrome-nickel," "chrome-molybdenum," "chrome-nickel-molybdenum" and "chrome-molybdenum-manganese" varieties. On cast structured or carbon steel drawing and forming dies. For creation of bearing surfaces and numerous other uses	Medium hard-alloy deposits which are machinable. Exceptional tensile strength. Work hardens in use. Resists abrasion and frictional heat. Takes high polish, and is austenitic or nonmagnetic. Resists metal pickup erosion and corrosion. Is not affected by heat treatment. Approximate hardness of deposits when peened 240–360 Brinell, 3000 kg.



Area on Plow Share Forging Die Refaced with Alloy Welding Electrodes Recommended for That Purpose

5. Applying the electrode.
6. Postheating (or tempering) the weld deposit or section.

An explanation of each step in the above welding sequence follows:

1. Determine the type of tool steel to be welded.

Determination of the type of tool steel to be welded will apprise one of the heat treatment involved and will govern the subsequent handling of the unit in the welding sequence.

2. Select the proper electrode.

Tool steel welding electrodes are available for all classifications of tool steels.

In making partial repairs of cutting edges or working surfaces, select the electrode that will match, as closely as possible, the heat treatment of the metal to be welded.

In making full repairs to cutting edges or working surfaces, choose the electrode with characteristics best suited for the type of work the unit will perform, taking into consideration any factors involving heat, abrasion, shock, thickness of metal to be cut or formed, and so on.

For repairing forging dies or facing cast structured or carbon steel drawing and forming dies, select alloy welding electrodes recommended for this purpose.

The size of the electrode to be used depends on the width and depth of the damaged area. In general, a $^3/_{32}$-in. electrode will repair a damaged area $^3/_{32}$ in. wide and $^3/_{32}$ in. deep. The same applies to the other sizes. Most tool steel welding electrodes are available in sizes $^1/_{16}$, $^3/_{32}$, $^1/_8$, $^5/_{32}$ and $^3/_{16}$ in. Always select the smallest electrode, especially on sharp cutting edges because less volume of heat is required. There is also less chance of creating sear marks, and after welding less grinding will be necessary.

3. Prepare the surface to be welded.

In making partial repairs of cutting edges or working surfaces, grind damaged areas to allow for uniform depth of finished deposit of at least $^1/_8$ inch.

In making repairs to entire cutting edges of tools or dies, rough grind the edges to be welded to an approximate 45° angle to allow for deposits of $^3/_{16}$ in. of finished metal.

On die units that require repairs over large areas, prepare surfaces so that finished deposits will be at least $^1/_8$ in. deep.

In preparing for repairs of cast structured drawing and forming dies, edges or areas to be faced should be prepared uniformly, so that finished deposits are at least $^1/_8$ in. Preparing for extremely long deposits for forming edges over large areas on cast-iron base metal, staggering of studs every 1 or $1^1/_2$ in. is advisable.

When preparing damaged forging die blocks for welding, areas to be repaired should be chipped, ground or machined as uniformly as possible to a finished depth of about $^3/_{16}$ in. for the inlay deposit, or, where necessary, to below the heat-checked depth.

4. Preheat the unit.

Knowledge of the type of steel to be welded will indicate the "draw range" temperatures involved. Never preheat beyond the minimum, nor exceed the maximum of the "draw range" temperature while welding. This is very important because if the unit is preheated to temperatures above the "draw range," hardness will be lost due to disturbing the original structure of the steel. Maintenance of temperature under minimum of the "draw range" in preheating and never above the maximum while welding, will result in retention of the original hardness of the steel so as not to affect the efficiency of the tool. This can be varied depending on the size of objects being preheated.

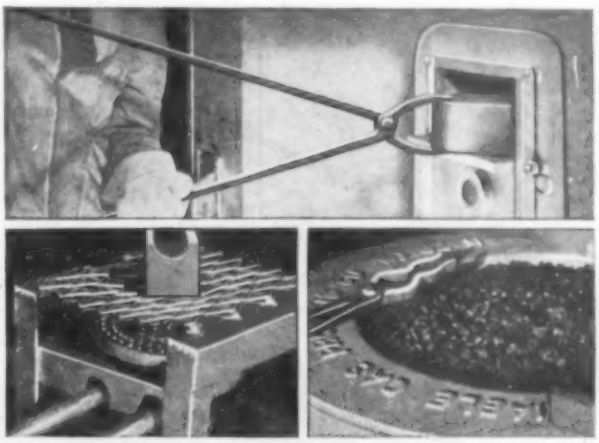
The following are recommended preheating temperatures to employ for the various types of tool steels:

Typical "Water Hardening" (water or brine quench), 250–450° F.
Typical "Oil Hardening" (oil quench), 300–400° F.
"5% Chromium Air Hardening" (oil or air quench), 300–500° F.
"High-Carbon–High-Chromium Air Hardening" (air quench), 400–1000° F.
"High-Carbon–High-Chromium Air Hardening" (oil quench), 400–850° F.
Typical "Tungsten-Chromium Varieties Hot Working," 1050–1200° F.
Typical "Chromium Varieties Hot Work," 900–1100° F.
Typical "Molybdenum High-Speed Steel," 950–1100° F.
Typical forging die blocks, 600–1100° F.

In composite fabrication the following preheats should be utilized:

Mild, medium carbon or high-carbon steel, 200–400° F.
S.A.E. Nickel-Chromium, 500–1100° F.

Elaborate preheating equipment is not necessary although it is desirable to use a controlled furnace when-



Typical Equipment Used to Preheat and for Drawing or Tempering

Top, controlled furnace; bottom left, hot plate; bottom right, lead pot.

ever possible because its even soaking heat assures saturation. A hot plate for preheating small units can be used. A slow baking heat results in saturation as the heating can be done from the opposite side of the area to be welded.

On extremely large units, preheating can be done by building a simple and effective brick oven. This can be fired with a gas flame from beneath, which will insure a slow steady heat. On extremely large units or long shear blades an oxyacetylene torch can also be utilized for preheating locally the areas to be welded.

To aid welding operators to determine and control temperatures, especially in preheating and tempering, there are available, in stick and pellet form, products that signal accurate desired temperature by a rapid melting action. They range in 25 and 50° steps between 125 and 1700° F.

5. Apply the electrode.

Reverse polarity is used in applying tool steel electrodes. Recommended arc currents are given in procedure sheets contained in all boxes of tool steel welding electrodes on the market.

Keep the temperature of the parent metal as uniform as possible during the welding operation to insure uniform hardness of weld deposit. Never exceed the maximum of "draw range" temperature of the metal being welded.

In welding cutting edges position the work, if possible, so that the deposit will flow or roll over the cutting edges.

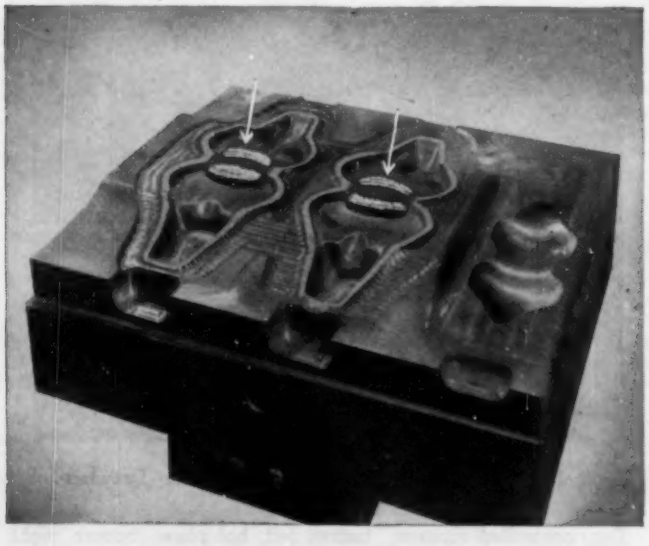
Always work slightly up hill, if possible, as gravity causes the deposit to roll back, and build up evenly. Gravity also causes the slag to roll back and keeps the crater clean. There is no need to weave the electrode in an intricate pattern.

In depositing beads, a slow travel is used to secure an even deposit and to assure more uniform fusion of the electrode with the base metal. Keep the area clean by frequent brushing.

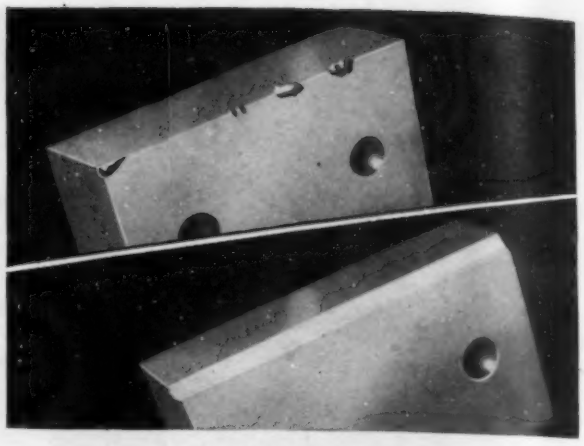
Peen all deposits thoroughly to offset shrinkage and stress. Peening is a mechanical means of relieving stresses.

It is important not to deposit excess metal in one pass. On final passes, retain beads as close as possible to finished size. This will eliminate excessive grinding.

To eliminate deep craters and the searing of sharp edges adjacent to the weld area when welding cutting edges, the arc should not be broken by rapidly pulling away the electrode. Pinch it off or lower the electrode gradually to get this effect.



Typical Repair of Forging Die



Preparation for Full Repair

When repairing parts of cutting edges, to eliminate craters and sear marks at the extreme end of the deposited metal the welding bead should first progress in one direction to within a short distance of the other. Then it should progress in the opposite direction and overlap the first bead.

In welding deeply damaged cutting edges or drawing and forming surfaces, start at the bottom and gradually fill up the damaged area, using a slightly higher amperage on the first and second bead than on the finishing beads.

In welding two or three dissimilar types of tool steel electrodes on one die unit, care must be exercised in applying the electrodes in sequence to their "draw ranges," that is, the first electrode applied must have the highest "draw range" and so on to the electrode having the lowest "draw range." This is important as it prevents the annealing of previously laid deposits.

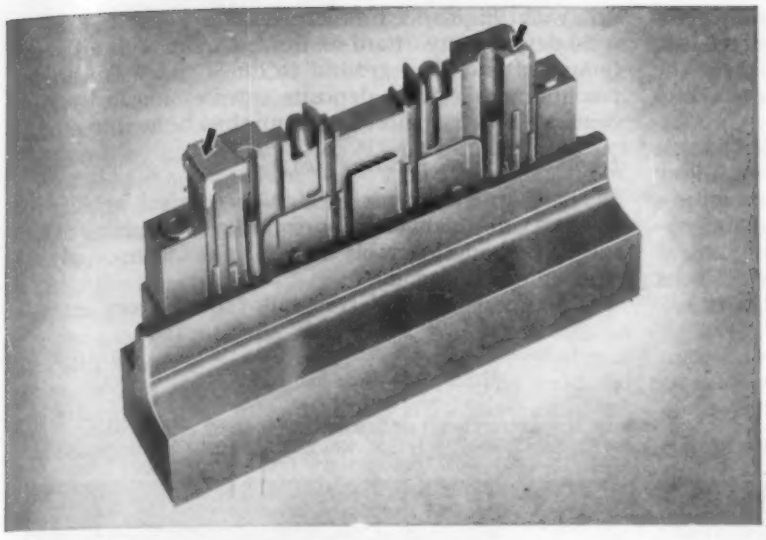
To effect repairs to entire cutting or forming edges of draw rings, female extrusion dies or similar circular parts, the "skip-weld" method should be used to insure even distribution of heat.

During the welding operation warpage or distortion is offset by preheating to expand the unit and by peening to stretch weld deposits thereby offsetting stresses. These are mechanical problems. The use of shims and clamps are helpful. For example, to prevent warpage of long shear blades approximately 1 in. thick by 5 in. wide, when welding along the entire edge, a reverse curvature is mechanically made to allow for the shrinkage or pull of the deposition. This is accomplished by inserting shims $^1/_{16}$ in. thick, $^1/_2$ in. wide, under the center line of each 14-in. lineal dimension. These shims should be used every 14 in. regardless of the length of the blade and are placed under the blade and clamped down on each end of the 14 in. dimension. Each 14 in. length should be completely welded and left to cool to room temperature before proceeding with the welding of the other parts of the blade. Do not weld more than three lineal inches before peening, as this will tend to relieve the stress set up in the welding operation by stretching the deposited metal.

6. Postheat (temper) deposits or sections.

After welding, units are allowed to cool approximately to room temperature and then tempered by reheating to recommended temperatures as outlined in the manufacturers procedure sheet. This is important, as postheating will serve as a tempering medium for the deposited metal, refining the grain structure and relieving any stress or strain set up in the welding operation.

As a general rule, in tempering deposits made to effect a partial repair, temper according to "draw range" temperature of the base metal. If units have been re-



Costly Hot Work Tool Steel Punch Reclaimed by Repairing with Hot-Work Tool Steel Welding Electrodes

paired over entire edges or working areas, temper the deposits according to the recommended "draw range" temperatures for the electrode utilized. All welded units should be tempered or drawn to meet requirements.

In gaging the proper tempering degree to be used, the minimum of the "draw range" temperature should be employed on units for light duty work. The maximum temperature of the "draw range" should be used on units for heavy duty work.

The same equipment can be used for postheating (tempering or drawing) as is utilized to preheat.

Composite Fabrication of Die Units (Recommended Welding Sequence).—When practical, die units can be compositely fabricated by utilizing a common steel of either mild, medium or high-carbon content or an S.A.E. steel as a base and applying water hardening, oil hardening, air hardening, high-speed or hot-working tool steel electrodes along cutting edges or over working areas. The same construction principles can be followed on cast structured or carbon steel drawing and forming dies, by depositing alloy electrodes along sharp contours, belt lines and radii. This practice provides ideal drawing or forming surfaces to better withstand abrasion, scoring, or fouling, incidental to these operations, thereby prolonging the life of the units.

To meet unusual conditions, existing tool steel units can be converted into composite ones by welding tool steel of superior quality on cutting edges or over working areas.

The following is the recommended welding sequence in composite fabrication.

1. Select the type of base metal to be utilized.

When utilizing water-hardening, oil-hardening or air-hardening electrodes in composite fabrication, mild, medium, high-carbon or S.A.E. steels can be used as base materials. For composite construction of units for hot work, S.A.E. steels of the nickel-chromium variety are recommended.

2. Select the proper tool steel electrode.

Select the electrode with characteristics best suited for the type of work the units will have to do, taking into consideration any factors involving heat, abrasion, shock, thickness of metal to be cut, formed, etc.

The size of the electrode to be selected depends on the amount of deposition to be made and in the type of preparation selected.

3. Prepare the surface to be welded.

There are four types of preparation for cutting or forming edges to be utilized in composite construction: the "angle type," the "90° shelf type," "straight shelf type" and the "self-created land type." With the exception of the last named, grind edges or surfaces enough to allow for at least $^{3}/_{16}$-in. finished deposit of metal. Choose the type of preparation most economical and suitable to the design of the unit.

In preparing for composite fabrication allow for two or more passes of the electrode. This will minimize the admixture of the electrode with the base metal and assure maximum uniform hardness as-welded.

On units that must be covered over large areas, prepare the base metal surface so that finished deposits will be at least $^{3}/_{16}$ in. deep.

In converting existing tool steel units into composite ones, rough grind edges to be welded to an approximate 45° angle to allow for deposits of $^{3}/_{16}$ in. of finished metal.

Do not prepare to finish size units for composite fabrication. Make them oversize to allow any distortion during welding and for finish machining, drilling, etc., after the welding is completed. On ring type or circular units oversize dimensions should be at least $^{1}/_{8}$ in., which will allow for finish grinding or machining to actual dimensions required.

For the composite construction of cast drawing and forming dies, using alloy electrodes, edges or areas to be faced should be prepared uniformly so that finished deposits are at $^{1}/_{8}$ in. Over extremely large areas of cast-iron units, staggering of studs is recommended. Nickel, copper-nickel or Monel electrodes can be used as intermediary electrodes. In these cases, provision should be made in the preparation, to allow for the additional deposits.

4. Preheat.

A preheat of 200–400° F. is recommended using mild, medium carbon or high-carbon steel as a base. Smaller units will take the minimum of the preheat range and large units the maximum.

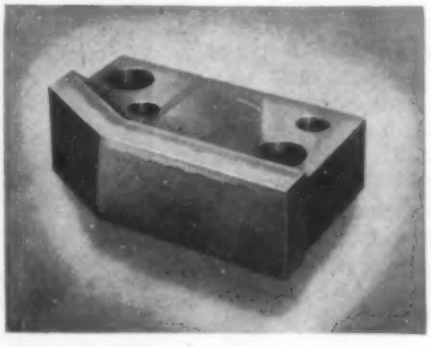
When using S.A.E. steels of the nickel-chromium variety a preheat of 600–700° F. is recommended.

5. Apply the electrode.

In composite fabrication the procedures to be utilized concur with those used in making repairs to existing tool steel die units.

6. Postheat (temper) the weld deposits.

On compositely constructed units, tempering should always favor the deposited metal. The base metal acts only as a retaining medium for the cutting or working edge of the desired tool steel. For the recommended tempering temperatures of weld deposits in composite fabrication, it is recommended to refer to the technical in-



Composite-Fabricated Die. The Base Is Mild Steel, the Cutting Edges "Hard-as-Welded" Deposits of Oil-Hardening Tool Steel

formation available on the electrode which is utilized.

When existing tool steel units have been converted into composite units, the tempering should always favor the deposited metal and not the base metal or units themselves.

All welded units should be tempered or drawn to suit the requirements. Tempering given toughness with very little depreciation of hardness, refines grain structures and relieves stresses and strains set up in the welding operations.

It is not necessary to temper deposits of alloy electrodes but a stress relief can be employed after welding.

Oxyacetylene Welding of High-Speed Cutting Tools

The welding and brazing of high-speed steel cutting tools came to the front during the recent war because of the abject shortage of high-speed steels. The most practical and feasible way to repair cutting tools, as indicated by experimentation and actual practice, is by the oxyacetylene welding method. Utilization of the metallic arc-welding method was generally discarded because of the concentration of extremely high heat at the arc, inducing checking and cracking of the tools being welded.

Cracked cutting tools are repaired by brazing with silver solder or other low melting alloys. However, this is a separate phase and is not covered in this paper.

Repairing High-Speed Steel Cutting Tools.—Repairs are effected by the oxyacetylene welding method to teeth and flutes on milling cutters, broaches, drills, ball and end mills, reamers, taps, cutting tools for lathes, planer and shaper, and specially shaped forming tools. In addition tool life can be prolonged by building up areas that are worn to the extent that they are no longer usable.

It is obvious that inestimable time and material can be saved and production facilitated by these types of reclamation. Valuable heat-treating time is saved because the "hard-as-welded" deposits of high-speed steel welding rods are as easily ground as conventional high-speed steel. The dimensional distortion sometimes experienced in heat treatment is also eliminated. Susceptibility to rebreaking is minimized because the weld deposits become integral parts of the tools.

Fabrication by Welding of High-Speed Steel Cutting Tools.—All types of cutoff, turning, grooving and special shaped forming tools, lathe centers, centerless grinder blades, etc., can be compositely fabricated by using a mild, medium-carbon or S.A.E. 1335 steel as a base. Blanks to which the high-speed steel welding rods are applied are machined in the same manner as is customary in preparing for carbide inserts. The requisite stock is built up with high-speed steel welding rods and as the weld deposits are "hard-as-welded," the tools are simply tempered and then ground to finish size. To facilitate machining, the weld deposits can be annealed and the compositely constructed tool can then be heat treated.

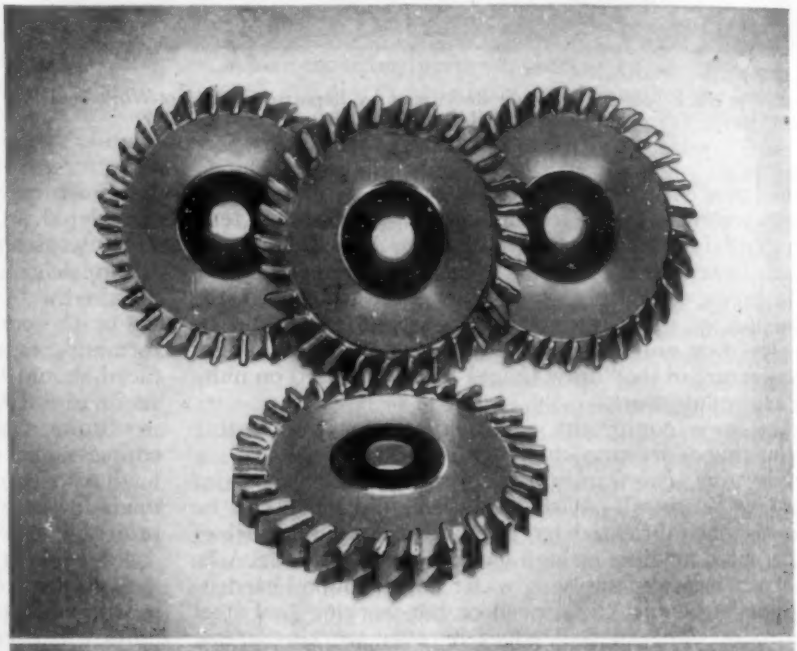
High-Speed Steel Welding Rods

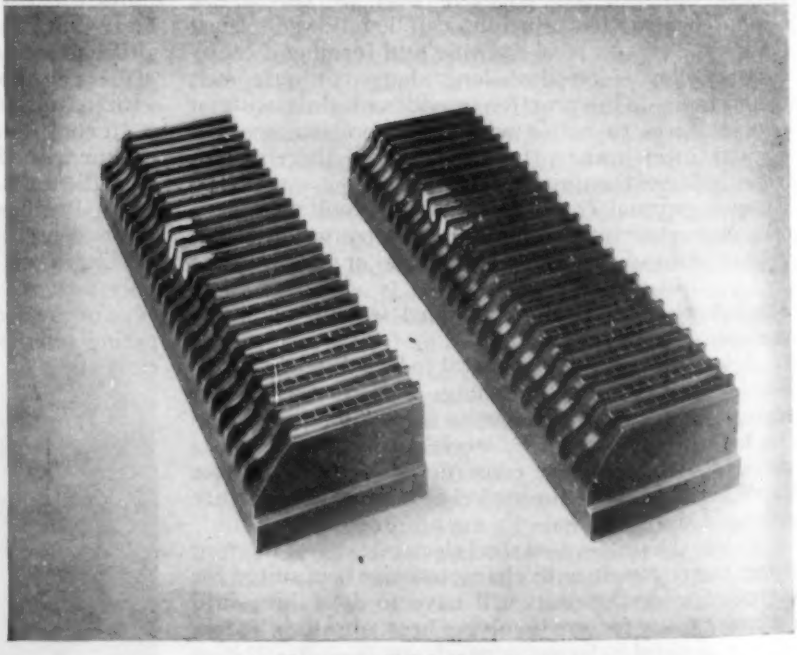
There are two types of high-speed steel welding rods that are commonly used for oxyacetylene welding of high-speed steel cutting tools as well as for compositely fabricating cutting tools.

One type is a cast ferrous alloy that incorporates the

H.S.S. Side Mills Refluted

These 7 x 1¼-in. side mills were rendered unusable by repeated resharpening. They were completely refluted on one side with H.S.S. welding rods to attain original width.





Repairing H.S.S. Broach Inserts

These large broach inserts were no longer usable because of four broken corners in the cutting flutes. The corners were built up with H.S.S. welding rod, and after finish grinding the inserts were as good as new

characteristics of high-speed steel from the standpoint of toughness, and at the same time provides wear resistance of cemented carbide. The weld deposits have cutting qualities of cobalt-tungsten high-speed steel. Rockwell hardness, secured as-welded and "drawn," approximate 60–66 on the Rockwell C scale. The weld deposits have exceptional red hardness and resistance to abrasion. The cast alloy rods are recommended for applications requiring the maximum resistance to abrasion such as on lathe centers, centerless grinder rests, spinning tools, etc.

The other type is a cobalt-molybdenum-tungsten high-speed steel welding rod which is a drawn wire. This type is easier to apply because the drawn structure tends to eliminate porosity in weld deposits which is sometimes experienced in applying the cast alloys. The weld deposits secured with these welding rods have excellent cutting qualities comparable to or excelling the typical high-speed steels combined with excellent abrasive resistant qualities. The hardness secured with welding rods of this type will approximate 61–65 on the Rockwell C scale. Contours are more easily maintained in utilizing the drawn rod rather than the cast rod. This minimizes the grinding necessary after welding. The drawn structure of these rods also minimizes the susceptibility to embrittlement and the weld deposits will take heat treatment similar to the typical high-speed steels.

Heat Treatment.—Typical heat treatment for cast ferrous high-speed welding rods follows: annealing temperature, 1600° F.; cool slowly in furnace. To harden, preheat to 1500–1550° F., transfer to a furnace at 2000° F., quench in air. Draw at 1000–1050° F.

Typical heat treatment for drawn cobalt-molybdenum-tungsten high-speed steel welding rods follows: annealing temperature, 1500° F.; cool slowly in furnace. Heat slowly, 2150–2200° F. Quench in oil or salt bath. Draw at 1000° F.

For tools used in intermittent cutting, it is advisable to resort to a second draw of 1075° F.

The weld deposits of both types of high-speed steel welding rods, the heat treatments of which are given above, are air hardening to a reasonable depth, as applied on hardened sections. Complete heat treatment, other than drawing or tempering, is generally not necessary. For best results in composite construction where the requisite build-up is heavy complete heat treatment is recommended.

Procedures.—In repairing high-speed steel cutting tools, the high-speed steel welding rods are applied by the oxyacetylene welding method, using a carburizing or an excess on the acetylene flame. The surfaces where the weld deposits are to be laid must be clean. When building or repairing damaged or worn cutting edges all edges and corners must be ground down to allow for deposit.

All surfaces to be faced should be brought to a sweating heat before attempting to fuse the high-speed steel welding rods to the parent metal. Flux should be utilized to aid in combating the oxidation of the highly alloyed high-speed steels. It is recommended that the flux be secured from the manufacturer of the welding rods being used. This flux should be used continuously during the welding operation. It is important that the flame of the welding torch penetrate below the outside oxide skin before applying the high-speed steel welding rod. Excessive puddling of the deposited metal should be avoided as it is not necessary because of the high fluidity of these rods. Caution should be exercised, in applying successive layers, to work out all oxides from previous deposits to eliminate the possibility of porosity.

For repairing hardened steel parts, a preheat of some 600–1000° F. is recommended, depending on the size of the object; the smallest object taking the minimum and the largest the maximum preheat; the range in between being proportionate. The maintenance of constant temperature, as nearly as practical, during the welding operation is of vital importance. In welding hardened high-speed steels, depreciation of hardness in areas adjacent to the weld may not be experienced in a reasonable degree if the flame of the torch is manipulated correctly.

After welding, all tools should be drawn or tempered, which will increase the hardness and toughness of the weld deposits. Generally a draw of 1000° F. is ideal.

In compositely constructing cutting tools, by utilizing a mild, medium-carbon or S.A.E. steel shank, preparation should be made to allow for a minimum depth of deposits of $^1/_8$ in. to minimize the admixture of the deposited metal with the base metal, with its resultant decrease of hardness. A preheat of 300–400° F. before welding is recommended. After welding, all tools should be drawn which will increase their hardness. As in the repair of cutting tools, the drawing temperature of 1000° F. should be utilized. In order to secure the maximum hardness a double draw, 1000° F. and subsequently 1050–1070° F., can be utilized.

Conclusion

Tool and die welding need not be mysterious or complicated. It is highly important to industry and the welding trade is becoming more and more cognizant of the great service it can render industry through the medium of welding tools and dies.

The E601X Electrode Group*

By Orville T. Barnett†

FOUR electrode classification numbers are found in the E601X group. These are E6010, E6011, E6012 and E6013. Actually these are five different types of electrodes because the E6013 group must be subdivided into E6013A and E6013B. The reasons for five distinct kinds of electrodes will be the subject of this discussion.

The E601X group of electrodes has a number of things in common. "E" stands for metallic arc electrodes, "60" indicates the minimum stress-relieved tensile strength in kips, "1" means all positions of welding and "X" is substituted for the final "0," "1," "2" and "3" representing different coating designs. Thus each specific electrode classification gives a clue to four separate properties to be found in the E-60-1-X notation.

As will be explained later, E6011 electrodes will do all the out-of-position welding jobs. Either a. c. or d. c. may be used as the power source. X-ray quality is good. Ductilities are fine. But some appearance or economic factors will suffer. The situation is analogous to that found in trucking where there are $^1/_2$-ton trucks, 1-ton trucks, 5-ton trucks and even 10-ton trucks. A truck operator could standardize on 10-ton trucks which would have ample load capacity. But the economy of operating a 10-ton truck continuously for $^1/_2$-ton loads could not be justified. Similarly the adoption of E6011 electrodes for all welding operations found in the E601X field involves economic penalties.

E601X electrodes are classified under A.W.S.-A.S.T.M. Specifications for Arc-Welding Electrodes (A233–45T). Complete information covering physical properties, testing and quality is given in this specification. In addition, a detailed appendix described as a Guide to A.W.S.-A.S.T.M. Classification of Iron and Steel Arc-Welding Electrodes points out the essential operating and application features of metallic arc electrodes. This specification and guide may be secured from either of the sponsoring societies. It is essential to a sound fundamental understanding of arc-welding materials. Coating formulations presented in this discussion have been taken from the Guide to the Classification of Arc Welding Electrodes with the exception of data given for the lime-ferritic electrodes.

All E601X electrodes may be applied in the overhead, vertical, horizontal-fillet and flat positions. Experience restricts overhead and vertical welding to the $^3/_{16}$ in. diameter and smaller diameters. Horizontal fillet welds are customarily deposited with the $^1/_4$ in. and smaller diameters. All diameters are usable in the flat position.

As far as tonal range is concerned, the piano will do everything that all the instruments in a symphony orchestra will do, but no one considers the piano a satisfactory substitute for the strings, horns and percussion instruments comprising the symphony group. E6011 electrodes can be used for all welding jobs if sufficient ingenuity is exercised, but the symphonic effectiveness will be lost.

Each electrode type has certain attributes that can be emphasized to provide a simple theme for discussion. For E6010–E6011 classes, the theme is *penetration*. E6012 class theme might be *production*. E6013A logically suggests *sheet metal*. E6013B centers around *fillet welding*.

E6010–E6011 Electrodes

The organic, all-position electrodes are noted for deep penetration. The arc digs into the base metal with decided forcefulness. Therefore the most popular welding applications are those where penetration is especially necessary. As a matter of fact, the penetrating qualities of the arc require good welding technique to avoid undesirable undercut.

Because E6011 electrodes were developed to duplicate the properties of E6010 electrodes as closely as possible, the two classes will be discussed together. The E6011 type includes an arc stabilizer put into the coating to permit satisfactory operation with alternating current. With the exception of this added feature, all of the other characteristics of the E6011 and E6010 classes are quite similar.

Of all the electrodes now classified in the E601X group, the E6010–E6011 types provide the best balance of mechanical properties with good usability characteristics. Where quality of weld deposit with particular emphasis on ductility in the vertical and overhead positions is of paramount importance, these electrodes should be used. X-ray soundness is good although some porosity is to be expected. Multipass welds exhibit good quality.

E6010–E6011 electrodes possess a deeply penetrating, forceful, spray-type arc. The thin, friable slag which does not always completely cover the weld metal in the flat, horizontal fillet and vertical down positions is readily removed.

Electrodes such as E6010–E6011 produce fillet welds with a rather flat contour. Ripples are rather fine and closely spaced in vertical welding as in Figs. 1 and 2, but are coarse in the horizontal fillet position shown in Figs. 3 and 4. The flat weld contour applies to welding in all positions but is illustrated in Figs. 5 and 6 for the horizontal fillet position only.

The E6010–E6011 electrodes are known as cellulosic types because the coating is quite high in cellulose, usually more than 30% by weight. Other covering ingredients include titanium dioxide, magnesium or aluminum silicates, a deoxidizer such as ferromanganese and a liquid sodium silicate binder. In addition to the foregoing ingredients for an E6010 coating, calcium and potassium compounds are added to the E6011 coating to increase

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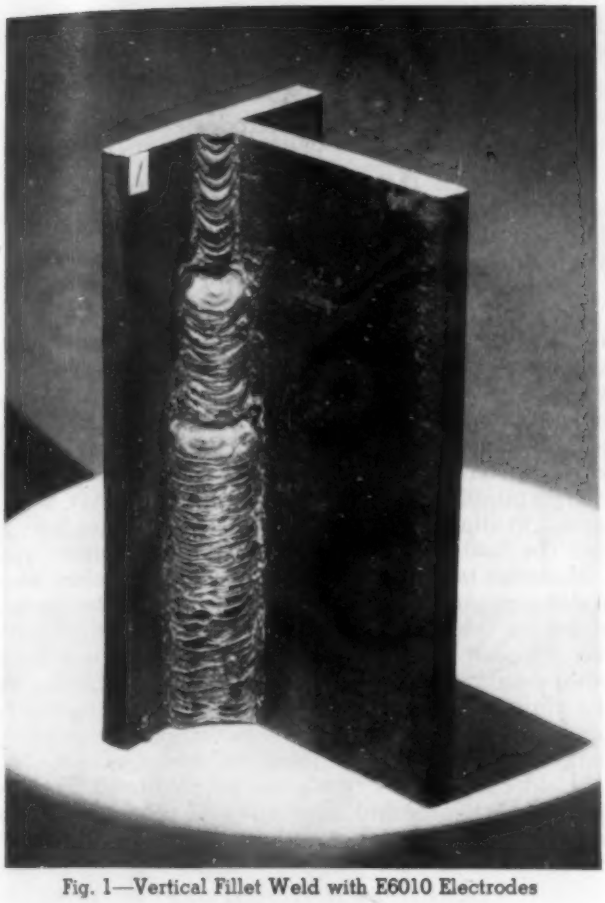

Fig. 1—Vertical Fillet Weld with E6010 Electrodes

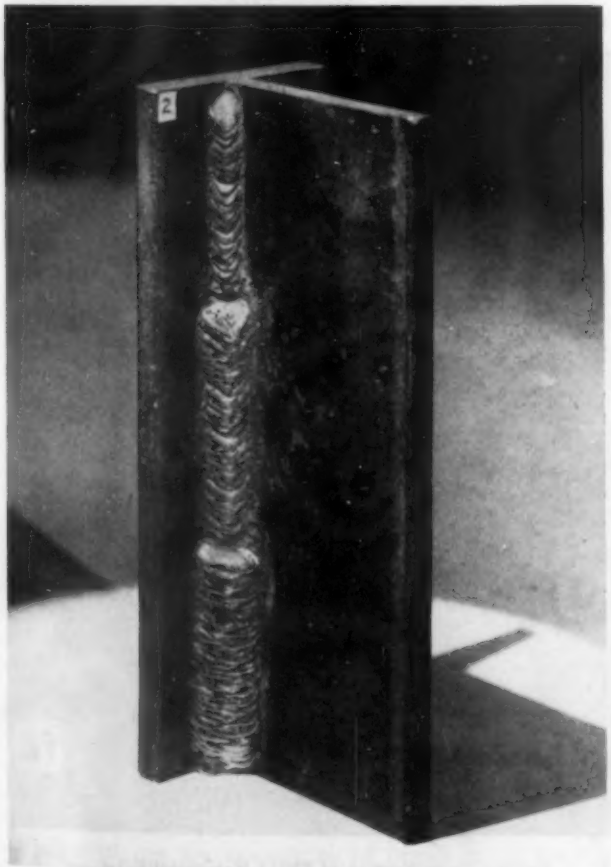

Fig. 2—Vertical Fillet Weld with E6011 Electrodes

Fig. 3—Horizontal Fillet Weld with E6010 Electrodes; Ripples Are Coarse and Irregular; Undercut at End of Crater Is Filled as Weld Progresses

arc stability for alternating current. The core wire is rimmed steel of the following analysis: carbon, 0.08–0.14%; manganese, 0.40–0.60%; phosphorus, 0.04% max.; sulphur, 0.04% max.; and silicon, 0.03% max. All of the E601X electrodes are made with the same core wire.

Because of the cellulosic covering, current values are somewhat limited. Excessive currents char the coating causing pitted weld deposits and considerable spatter. Flat position butt welds may show surface pits or porosity unless the arc voltage is increased by a long arc. Usually the welder so adjusts his technique as to bring about a weld of proper appearance. In general, the manufacturers' recommendations regarding optimum currents and voltages should be respected to obtain the highest quality weld metal.

Direct current, reverse polarity (electrode positive, work negative) is specified for Class E6010. Alternating current; direct current, reverse polarity; direct current, straight polarity are listed in order of preference for Class E6011.

Fields of application are based on the properties of the electrode. Most applications will be found in mild steel fabrication although galvanized steel and low-alloy steels may be joined with cellulosic electrode deposits. Indus-

Fig. 4—Horizontal Fillet Weld with E6011 Electrodes; Is Slightly Smoother Than E6010 Weld

tries using these electrodes extensively are quite numerous, including shipbuilding, structural work, field storage tanks, pressure vessel fittings and piping.

For tack welding heavy assemblies, E6010–E6011 electrodes have no equal. The deeply penetrating arc bites into the plates allowing subassemblies to be fitted prior to final welding. Tack welds are strong enough to permit large assemblies to be transported by crane from fit-up locations to welding areas. This same penetration factor is utilized to complete butt welds in plates from $^3/_{16}$ to $^3/_8$in. in thickness without the necessity of chipping the joint to insure 100% penetration. Usually $^5/_{16}$- or $^1/_4$-in. electrodes are selected with one bead being deposited on each side of the joint.

Much shipbuilding fabrication is completed on the ways. Vertical and overhead welding are carried out with cellulosic electrodes. Quite a bit of structural welding is done in catch-as-catch-can positions in the field where the qualities of the E6010–E6011 electrodes are used to good advantage. For years, large field-erected storage tanks have been constructed with this type of electrode. Pressure vessel fittings and reinforcing pads have generally been welded to the shells with organic or cellulosic electrodes. Both piping and pipe lines have found the usability and weld quality attributes of this electrode class ideally suited to the welding problems in these fields.

Cellulosic electrodes provide deep penetration for tack welding. In addition, this same feature makes complete and sound butt welds in thinner plates without chipping the land zone. Weld appearance in vertical and overhead fillets is good. Coarse and rather irregular ripples detract from eye appeal in the horizontal fillet and flat positions. In general, this classification of electrodes is slow. With present-day labor costs emphasizing the need for speed, E6010–E6011 electrode consumption has fallen from first place to a definite second position behind the E6012–E6013 classes. Work applications combined with cost considerations have wrought this change.

E6012 Electrodes

Production is the theme for E6012 electrodes. The covering is designed to stand very high currents without detrimental welding effects. None of the other E601X will permit as much current as the E6012 class.

There are two varieties of E6012 electrodes. One is "cold" and the other is "colder." The first type is the more popular. This coldness feature permits the application of $^5/_{16}$-in. electrodes to $^1/_4$-in. plates where butt welds of good appearance at extremely fast travel speeds are commonplace. Horizontal fillet welds are equally neat looking when made at high rates of travel along with considerable current. Of course, there are different interpretations of the term "cold" and as may be expected, welding designers have shown a greater tendency to vary the fluidity of E6012 deposits than any other type.

Moderate penetration of both "cold" and "colder" electrodes is responsible for the selection of E6012 class electrodes for bridging gaps created by poor fit-up. However, the ease with which cold electrodes overcome bad fit-up should not lull any fabricator into the false security of permitting sloppy fit-up. Poor fit-up is just what the name implies. And anything less than good commercial fit-up increases costs and penalizes weld appearance.

"Colder" E6012 electrodes as differentiated from the normal "cold" ones find employment in fabricating higher carbon steels where pickup of parent metal must be minimized to avoid weld cracking. Some plants prefer the "colder" design for unusually fast production assemblies. The over-all welding characteristics of the "cold" E6012 are preferable in all but a few special instances.

Tensile and yield strengths of E6012 weld deposits are

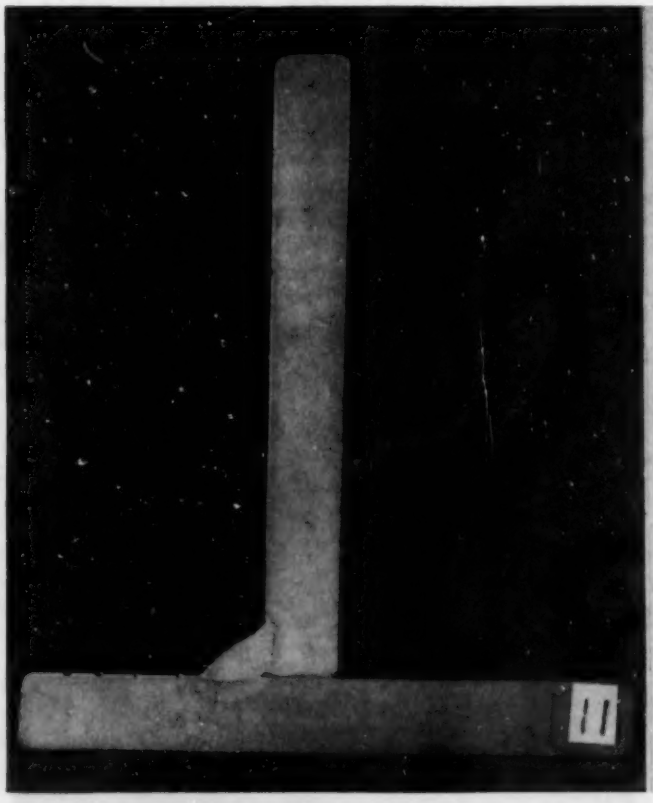

Fig. 5—Cross Section of E6010 Horizontal Fillet; Displays Comparatively Flat Face

Fig. 6—Cross Section of E6011 Horizontal Fillet

definitely higher than those for the E6010–E6011 classes. Moreover, the better strength is accompanied by a lesser ductility. Perhaps too much emphasis has been placed on ductility as E6012 electrodes properly used certainly possess ample ductility. Multipass welds may show porosity on X-ray examination unless special techniques are adopted. Single-pass welds usually satisfy radiographic standards.

As pictured in Fig. 7, E6012 electrodes will produce vertical fillet welds. But in spite of their classification as all-position electrodes, the E6012 type is seldom used in vertical and overhead work. By far the most extensive use is found in single-pass horizontal fillet welds with flat position welds running a close second.

Medium penetration is characteristic of E6012 electrodes. The arc is rather quiet. Spatter is the least of any E601X electrode. This feature is important to the reduction of cleaning costs prior to painting. If the areas adjacent to the weld are protected with a spatter-resisting paint, simple wire brushing may be all the cleaning needed. A dense slag completely covers the deposit

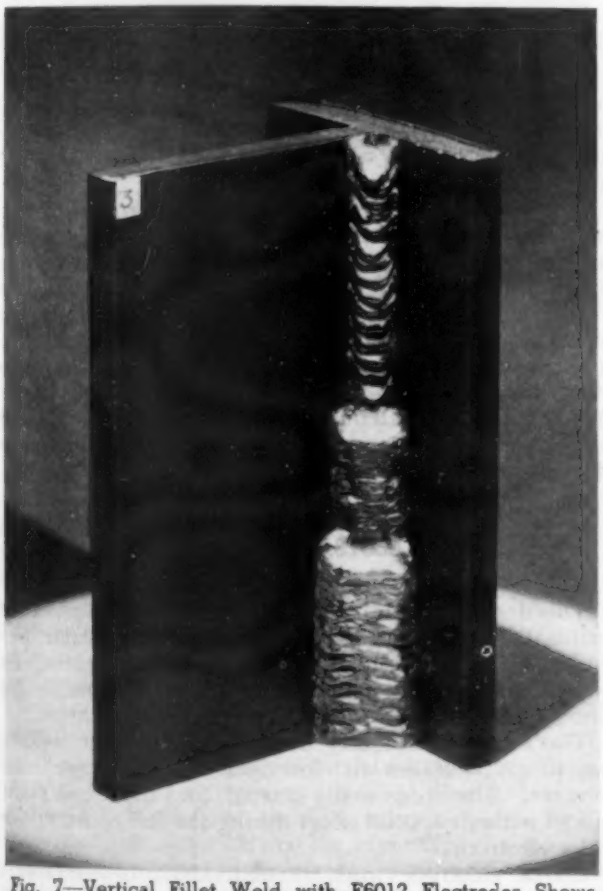

Fig. 7—Vertical Fillet Weld with E6012 Electrodes Shows Coarse Ripples and Very Convex Deposit

and is easily removed after the weld cools. When multipass fillet welds are made with stringer beads, slag removal may be delayed until the weld is completed because the slag does not interfere with subsequent beads.

Titania or rutile type coverings are common to E6012 electrodes. In most formulations, the rutile is more than 35% by weight. Other ingredients are likely to include complex aluminum silicates, ferromanganese, cellulose, calcium and potassium compounds with liquid sodium silicate.

Bead contours are convex as in Fig. 7 for a vertical fillet weld, as in Figs. 8 and 9 picturing horizontal fillet

Fig. 8—Smooth, Uniform Ripples Characterize Horizontal Fillet Welds Made with E6012 Electrodes

welds. Convexity in horizontal fillets or butt welds is not too great. Multipass vertical welds become less convex as the number of beads is increased with the third and succeeding layers becoming flat. Both horizontal fillet and butt weld profiles demonstrate neat, closely spaced ripples of pleasing appearance. Weld convexity in butt welds may be reduced by welding slightly downhill.

Either alternating current or direct current, straight polarity may be selected with the E6012 electrodes. Direct current, reverse polarity works well, too, although at some sacrifice of speed.

Although most welding with E6012 electrodes is done on mild steel, low-alloy steels and higher carbon steels have been fabricated with this type of electrode. The

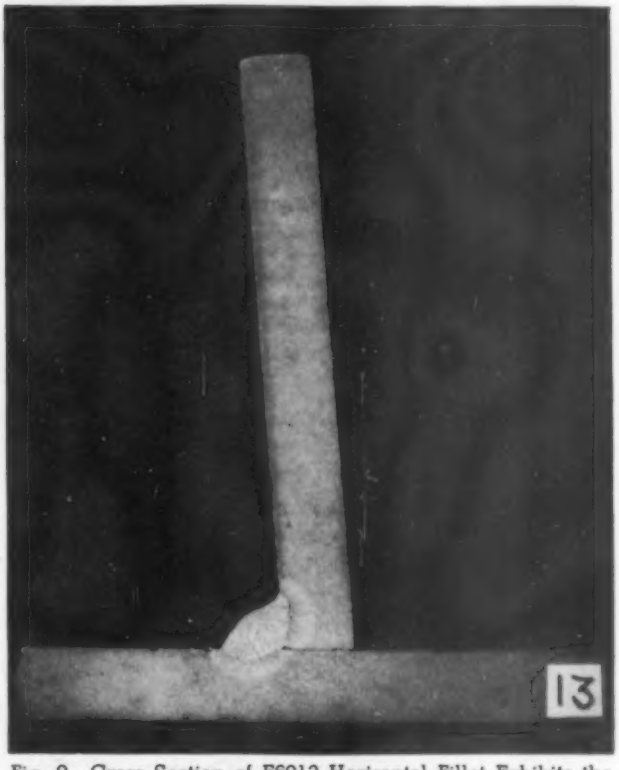

Fig. 9—Cross Section of E6012 Horizontal Fillet Exhibits the Greatest Convexity of the E601X Group

limited penetration reduces pickup of alloys and carbon thereby minimizing cracking of the weld deposit.

E6012 electrodes are often called "general-purpose" electrodes because of the many uses to which this type has been put. Among the industrial applications are general maintenance work, light and heavy structural fabrication, special truck body construction, storage containers from milk cans to all-welded oil field stock tanks and light machinery parts.

Maintenance departments associated with heavy manufacturing industries build many special pieces of equipment. In this work, as well as in much repair welding, the rutile type electrodes have established a well-deserved reputation.

Both light and heavy structural work lends itself to welding with general-purpose electrodes. Among the light structural jobs are walkways, small bridges, safety guards, oil well derricks, steps, platforms, and so on. Bridges and buildings fall into the category of heavy structural work where the E6012 electrodes have proved to be very good.

Thousands of special truck bodies are tailor made to special requirements by welded designs executed with rutile coated electrodes. Chassis modifications have been carried out similarly. In all cases, the speed and low spatter of the E6012 class led to the selection of this type.

All sorts of storage containers from light gage containers such as milk cans to much larger and heavier containers such as oil field crude stock tanks are built with E6012 electrodes. There are many companies engaged in selling welded containers. Competition is very keen placing a premium on the lowest possible manufacturing costs. The almost universal adoption of rutile electrodes for this work is explained on the basis of high electrode productivity, excellent welds of attractive appearance and low spatter which keeps cleaning costs at a minimum.

Fig. 10—Vertical Fillets Made with E6013A Electrodes Have Coarse Ripples and Characteristic Convexity of "Cold" Deposits

Fig. 11—E6013A Horizontal Fillet Weld Ripples Are More Smooth and Uniform than E6012 Welds

The physical properties of E6012 electrodes together with their good operating qualities make them quite useful for light machinery parts. Such equipment is often made at low cost of light structural shapes and thin plate.

The many E6012 electrode qualities are nicely balanced to give fine production rates. All of the examples of uses were merely representative of the thousands of structures joined by weld metal from rutile electrodes. Applications are both numerous and increasing with more E6012 electrodes consumed in postwar welding activities than any other E601X electrode type.

E6013A Electrodes

This design of metallic arc-welding electrodes possesses unusual arc stability which leads to spectacular performance for sheet metal welding. Both welding engineers and welding operators agree in the standardization on E6013A electrodes for sheet metal fabrication.

The same arc stability desired in light gage welding provides advantages with low open-circuit voltage transformers. The arc is easily started, and the arc is maintained without special effort during the full consumption of an electrode.

E6013 electrodes must be subdivided into two groups, E6013A and E6013B. The E6013A group has been available for sheet metal welding since prewar times. The E6013B group represents a wartime development intended for heavier welding. Very likely, E6013A and E6013B will be given separate classification numbers such as E6013 and E6014 to avoid confusion.

In general, the mechanical properties of E6013A electrodes are similar to those of Class E6012. Likewise, X-ray soundness is like E6012 although with the $^5/_{32}$ and $^1/_8$ in. diameters, X-ray quality rivals that of the E6010-E6011 classes.

A medium penetrating, soft arc is typical of this class. A comparatively thin, friable slag covers the deposit. Slag coverage may be incomplete in some positions. Slag removal becomes much easier when the weld has

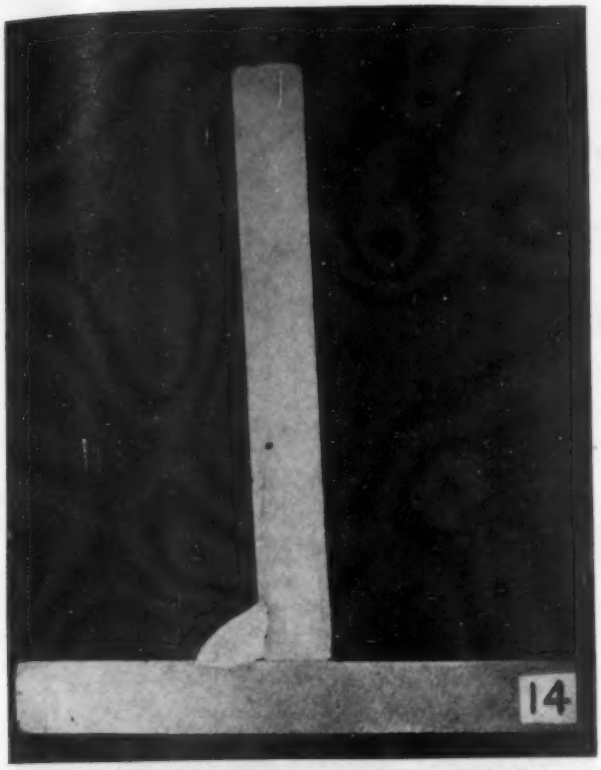

Fig. 12—Because E6013A Electrodes Are "Hotter" Than E6012, Horizontal Fillet Weld Cross Sections Disclose Less Convexity

been allowed to cool. Although this same factor is involved in all slag removal, the difference becomes more noticeable with those electrodes possessing a slag such as that found on E6012 and E6013 electrodes. The presence of scale can make the slag more adherent and thereby increase cleaning problems.

Figure 10 shows a vertical up fillet made with E6013A electrodes. Performance is slightly better than E6012 due to the hotter arc and more fluid deposit. However, vertical down welding is almost the only vertical work performed with the E6013A electrodes. Vertical down is the best and fastest position for sheet metal welding. For comparison with the other E601X electrodes, Fig. 11 illustrates the smooth, fine ripples in horizontal E6013A fillet welds. Figure 12 demonstrates the convexity to be expected with E6013A horizontal fillets.

The most up-to-date sheet metal welding depends upon excellent fit-up to bring about fast production rates. It is not uncommon for 16-gage steel to be welded vertically down with a $^{5}/_{32}$-in. electrode. Similarly, 14-gage steel is joined with vertical down welding using a $^{3}/_{16}$-in. electrode. One application showed the advantage of attempting to increase electrode diameter and current. In this case, the electrode diameter was increased from $^{3}/_{32}$ and $^{1}/_{8}$ in. to $^{5}/_{32}$ and $^{3}/_{16}$ in. The quantity of electrodes required for the job was reduced from 4 lb. per unit to $^{3}/_{4}$ lb. per unit. Naturally, the production speed was increased by several hundred per cent.

Coverings, too, are like the E6012 design. Rutile, silicious materials, cellulose, ferromanganese together with a liquid silicate binder will be found in the coating. Chemicals containing readily ionized constituents are incorporated into the coverings to allow the easy establishment and maintenance of an arc at low current and low open-circuit voltage.

Current values are somewhat limited in the upper range. Lower current limits enable E6013A electrodes to operate well at current values below those of any other E601X class. The advantage of this factor in sheet metal welding is obvious. Alternating current or direct current, straight polarity, lead to equally good performance. E6013A electrodes may also be used with direct current, reverse polarity.

Applications for light gage welding in the aircraft industry and for sheet metal in the automotive and other industries are the most common. E6012 electrodes were originally approved for aircraft welding. It was not long before a distinct trend to the E6013A design became noticeable. The greatly improved arc stability of the latter explains this migration in demand. Usually alloy pickup is sufficient to give ample strength when E6013A electrodes are chosen for alloy tubing welds.

Automobile bodies, stoves, refrigerators, ducts for heating and air conditioning, safety guards to protect workers from moving gears and machinery, metal furniture, thin-walled storage tanks, light structural units, steel window sash, ornamental iron work and many other related welding applications may be accomplished to best advantage with E6013A electrodes.

E6013B Electrodes

In wartime fabrication, E6013B electrodes exhibited desirable fillet welding characteristics. Production in the postwar era finds these same fillet welding characteristics in demand.

Whereas E6013A electrodes enjoy their greatest popularity in diameters from $^{1}/_{16}$ to $^{3}/_{16}$ in., E6013B electrodes are commonly selected in larger diameters from $^{5}/_{32}$ to $^{5}/_{16}$ in. As the larger diameters suggest, these electrodes are useful in heavier fabrication.

The excellent mechanical properties that can be de-

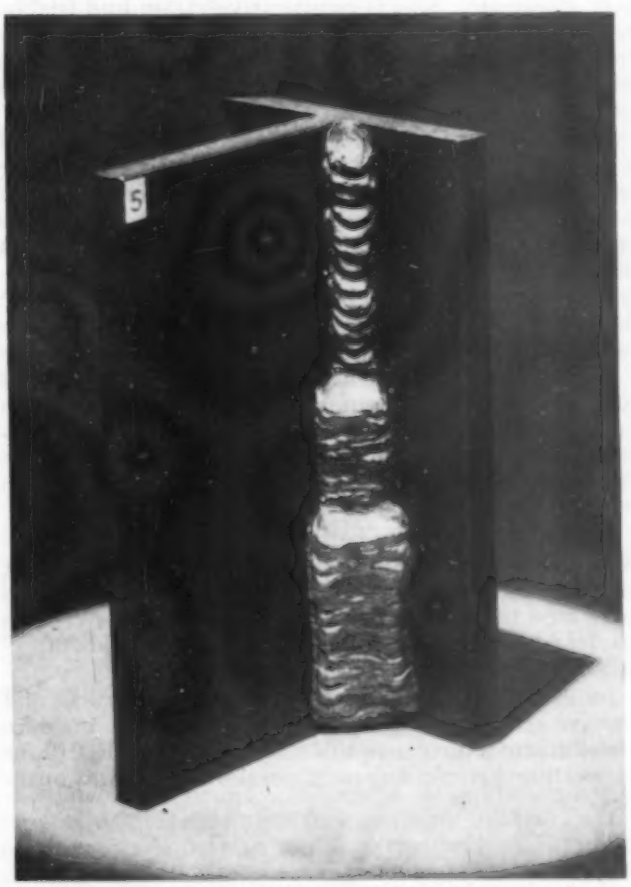

Fig. 13—Vertical Fillet Weld with E6013B Electrodes Is the Least Coarse of the "Cold" Series; E6012 and E6013

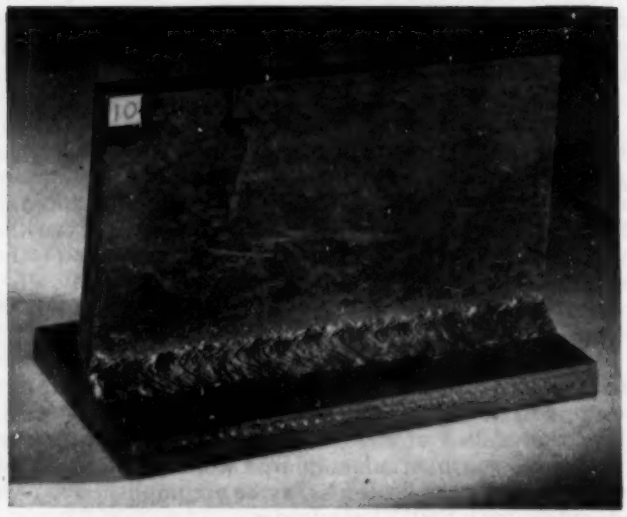

Fig. 14—Smooth, Fine, Uniform Ripples Are Common in E6013B Horizontal Fillet Welds

veloped by the $^5/_{32}$-and $^1/_8$-in. diameters of E6013B electrodes led to some early confusion of typing. There was some question as to whether E6010, E6011, E6012 or E6013 was appropriate. Now an interim agreement has been reached on E6013 with a possible ultimate resolution of the question by establishment of an E6014 class. Ductility results vary with welding current and technique suggesting close adherence to manufacturers' current recommendations to develop the best ductility. X-ray soundness is surprisingly good surpassing all of the other E601X types.

E6013B electrodes give moderate penetration with a soft, stable arc. Slag is comparatively thin and friable. In the horizontal fillet position, the slag may curl away from the weld bead on cooling. This feature has led some welders to call the slag "self-cleaning." Slag coverage is good.

Figure 13 shows the appearance of a vertical fillet weld with E6013B electrodes. Here a whipping technique was employed to compare all electrodes on the same basis. A weaving technique more like that common to stainless steel welding would have been better. Figure 14 illustrates a horizontal fillet weld where E6013B electrodes really shine. The beads have a flat face with very fine, evenly spaced ripples. The flat fillet section is easily appreciated in Fig. 15.

E6013B electrodes are also rutile types like E6012 and E6013A. Rutile, aluminum silicates, cellulose, ferromanganese and a liquid silicate binder comprise the covering. As is true of the E6013A design, liberal amounts of chemicals with arc stabilizing ions will be found in the coating.

Higher currents may be selected for E6013B as compared with E6013A electrodes. For this reason, faster production rates become possible. The weld deposit is more fluid than most of the other E601X classes yet sets up quickly enough to permit lap and fillet welds of excellent appearance on $^3/_8$-in. and lighter plates.

Industrial uses include railroad cars, heavy trucks and massive earth-moving equipment. One large pressure vessel manufacturer uses this class in place of E6010 for the welding of reinforcing pads, nozzles and manway openings.

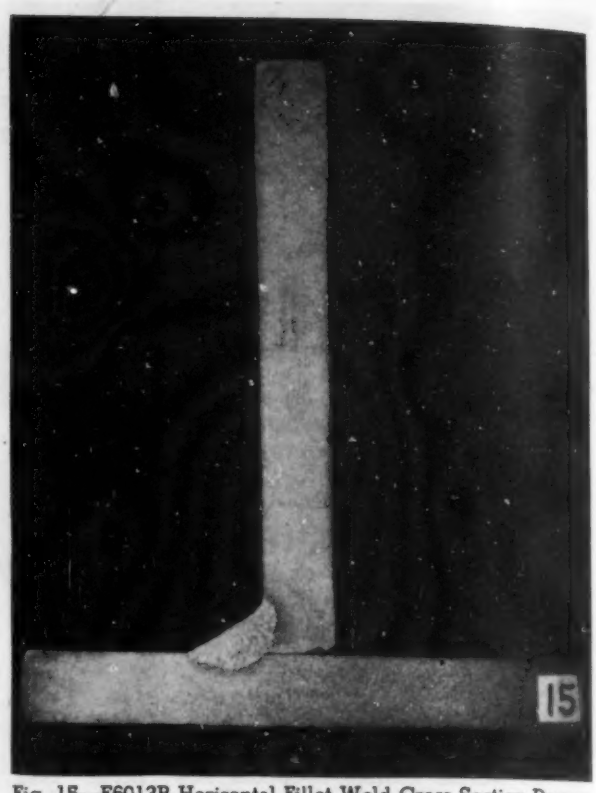

Fig. 15—E6013B Horizontal Fillet Weld Cross Section Demonstrates the Flat Profile Possible with This Type

Although E6013B deposits are generally less ductile than those produced by E6010 electrodes, weld soundness is apt to be better. E6013B electrodes appeal to welding operators because handling characteristics are very attractive. In vertical welding, heavier fillets and thicker layers become possible. The decreased tendency of the weld metal to run out is the reason.

A comparatively recent development of the mild steel lime-ferritic electrodes foretells the addition of another candidate for E601X classification. Because these electrodes are scheduled for a more complete discussion in another article, only a brief high spotting will be attempted here.

The new lime-ferritic electrodes may be used in all positions with a possible limiting diameter of $^5/_{32}$ in. for vertical welding. Spatter is less than any other E60XX type. Perfect X-ray soundness is attainable with good technique. Underbead cracking is practically eliminated on hardenable steels. Strength properties meet E60XX requirements, impact strength at room temperature is more than double the best of the other E60XX classes and retains its advantage to $-50°$ F., and ductility as measured by elongation and reduction of area is more like that of E6020–E6030 types than the other E601X electrodes.

Certainly five, and most likely six, commercial electrodes are available for the four current E601X classes. Therefore, additional E601X listings must be imminent. Not all welding fabricators need all six of the available all-position electrodes. Still every user of electrodes who is interested in quality deposits and welding costs should be familiar with the special properties of each class. Only in this way can he be sure that his reputation for quality and his competitive position are secure.

Repairing Contractors' and Steel Mill Equipment with Manganese Applicator Bars*

By L. A. Davis†

THIRTEEN and a half per cent manganese applicator bars are made in all shapes and sizes such as round bars 16 to 20 ft. long, 3/8 in. in diameter up to 1 1/2 in. larger on request; square bars 16 to 20 ft. long; flat bars 2 to 8 in. wide; all thicknesses 16 to 20 ft. long and, for those who use large amounts or require wider pieces, 4 ft. wide by 12 ft. long. Some are made of manganese nickel steel so they can be fabricated, heated red-hot, bent to desired shape without losing their strength and ductility as would be the case if Hadfield manganese were used, or if heated to 660° F. while welding.

Manganese nickel steel costs considerably more than boiler plate, armor plate, etc., but many feel that ability to be fabricated, good weldability, 140,000 lb. to 150,000 lb. tensile strength compared with 75,000 lb. psi. for carbon steel and 72% ductility compared with 25–28% ductility for low-carbon steel or 12–15% ductility in high-carbon steel make it just what they need. Most alloy steels must be heat treated to have these physical properties and would lose it when being fabricated. These manganese applicator bars can be bent cold. Up to 1/2 in. but with 3/4- to 1 in.-flats, they are better heated, very slowly, to a dull red so the heat can become the same all the way through; then, after they cool to a black heat, bend them. If spot heated with an acetylene torch, they can be drilled with a high-speed drill, cooling drill a couple of times or, if a special drill is bought that will easily drill through a file, they can be drilled cold. It takes 2 1/2 min. to put a 3/4 in.-hole in a 3/8 in. 13% unheated manganese plate. The drill must run 500 rpm. and be made for this purpose. The manufacturer can tell you where to obtain these drills and countersinkers, and how to use them.

Fig. 2—3/8 Round on Lip, Etc., Still on After 14 Hr. a Day One Year

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† Vice-President, Stulz-Sickles Co.

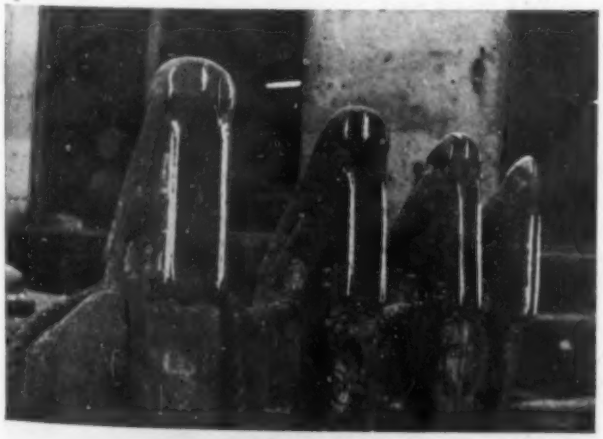

Fig. 1

Back of teeth as well as the points should be built up. Round manganese nickel bars were attached with one heavy pass on each side. Several new wedge bars can be worn off before these are worn off. It also eliminates breakage of teeth back of weld.

Where Used

Manganese applicator bars should not be used where you have abrasion only and no impact, as abrasion-resisting plates are cheaper and will wear as long in such places.

Where there is impact, digging in rock as in a place where something hard drops on a part to be built up, and where you want something stronger and tougher, more ductile than any other, unheat-treated metal, manganese nickel steel applicator bars are the answer.

Usually anything which is hard enough to wear well is low in ductility, a little brittle even if its tensile is above 100,000 psi.; usually it has a ductility of 12 to 15%, whereas manganese nickel steel has a ductility of 72%, and many times great ductility is very important, especially around bucket lips.

Round Bars

Round nickel manganese bars can be put up across the back of teeth if digging in rock as shown in Figs. 1 and 2 and one needs only to build up the back of the tooth about every fifth time a new point is put on; if digging in fine dirt, a flat piece of high-carbon steel is better as it covers the whole tooth.

Fig. 3

Fig. 4

Flat Manganese Nickel Steel Bars Welded Inside Large Dragline Bucket. Pictures Taken After Over a Million Tons Were Handled. When Considerable Fine Material Is Going Through Use Thinner Pieces and Place Just Far Enough Apart So Welding Is Possible, These Were Found to Be Too Far Apart

The round bars can be used on small bucket lips, $^3/_4$ to $1^1/_2$ yd., as shown in Fig. 2. This bucket was used one year, two shifts a day, up to the time the picture was taken and was not yet worn off. Notice also the round bars on heel of bucket after one year's use.

Round bars can be used in dredge pumps to speed up the rebuilding, and one can deposit 15 lb. a man hour by welding round bars on, while by the drop-by-drop method of welding one can only put down 4 lb. per hour and would produce three times as much heat and shrinkage strains.

Flat Bars

Many contractors, steel mills and quarries are welding flat bars inside buckets as shown in Figs. 3 and 4, and as soon as the bucket becomes dented and thin, they lay 4-in. wide bars a few inches apart from front to back on bottom and sides. If digging where there is considerable rock, the rocks ride on these bars and the bucket is protected.

In order to get the same strength and wear when using boiler plate one would need to put in a piece $^3/_4$ in. thick, whereas a $^3/_8$-in. piece of nickel manganese steel would have as much strength and would *keep down the weight of the bucket*. This does not put such a load on gears, motors, etc. On large buckets, 20- to 32-yd. jobs, $^3/_4$-in. plates are used to get the same service as a $1^1/_2$-in. plate of soft steel would give.

Many use flat manganese nickel steel bars and pieces of plates on the outside of buckets, when they are worn thin (see Fig. 6).

One large stripping contractor has found that if the outside or bottom of the 25-yd. bucket lip is left uncovered, a piece of the lip is soon ripped out at the place where the tooth goes in a pocket and, if hard surfacing rods only are used, the best ones stay only two weeks, while if $^1/_2$-in. flat manganese bars are welded on, the bucket can be used from 6 weeks to 2 months without any repair work at that point and no part of the lip is worn off to weaken it.

On the inside or tip of the lip the operator sticks to hard surfacing rods because it would make the lip too thick to put plate on outside and inside both before sending it out to be used the first time, although, on one that has been worn thin, $^3/_8$-in. pieces are often put on the top and $^3/_8$- to $^1/_2$-in. pieces on the underside or bottom of the lip along with round applicator bars made of manganese nickel steel.

In steel mills, flat and square bars are used on hot coke cars. On lips of clam sheel buckets that handle hot slag,

Fig. 5

This picture shows 1-in. flat manganese nickel steel bars, 4 in. wide, inside a large dragline bucket, after five million tons of rock and dirt were handled. In repairing, small buckets usually $^3/_4$ to $^1/_2$ in. by 4 in. are used.

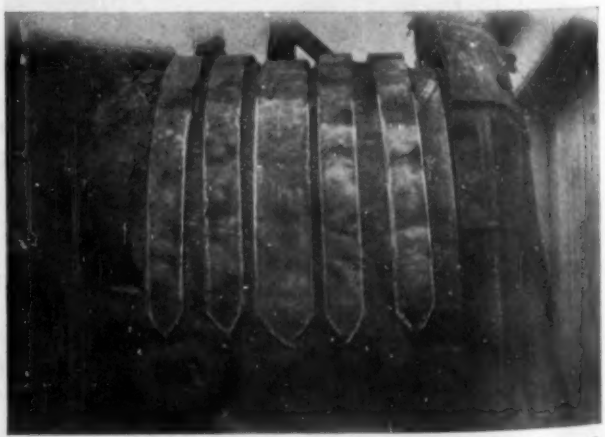

Fig. 6—This Picture Shows Flat Manganese Nickel Steel Bars 4 In. and 6 In. Wide Welded Over the Carbon Steel Plates on the Bottom of a 9 Yd. Dragline Bucket, Looking at the Bucket Upside Down from the Back

some abrasive resistant steels are softened if they are heated above 400° F., while manganese nickel steel can be heated red-hot and allowed to cool in still air without changing its hardness or strength.

In cinder dumps in steel mills and many other places a great saving is found by building up the worn tractor tread cleats with manganese nickel steel applicator bars, shaped properly for that purpose so that it is possible to use a large enough electrode to put one heavy pass on each side ($^1/_4$-in. rod on the larger tractor) so that speed can be obtained and no second pass is necessary. If a heat-treated piece of carbon steel were used, such speed and heat would soften the parent metal while no injury would be done to this manganese. It is well to cut the applicator bars 1 to $1^1/_2$ in. shorter than the original cleat, as the ends are rounded on each end and it eliminates a lot of puttering around welding in the open space at each end and also saves many feet of bar. A manganese nickel steel bare electrode can be used to attach these unless an a.-c. machine is used, in which case a coated manganese rod can be used.

Attaching Applicator Bars

When attaching applicator bars it has been necessary until recently to use a chrome-nickel steel rod for the first pass, because it is very difficult to get a good weld in a crack or narrow place with a bare manganese electrode on account of the magnetic blow and of being unable to weave the electrode in a $^3/_4$-in. wide crescent motion as one needs to do in order to melt down every part of the weld the second time and allow all the gas to escape before solidification.

There are coated manganese nickel steel electrodes available which enable one to do this job now with manganese, with the great advantage that the welds can be flame cut later on when it is desired that the bars be cut off. Manganese nickel steels being approximately 30% stronger and more ductile than the 18 chrome–8 nickel steel and costing no more, most large users of wedge bars, for teeth, and flat bars and round bars have already changed.

Where more than one pass is to be put on, it is better to use bare manganese because the welds are air conditioned, i.e., the air reaches it quicker, and the faster manganese cools, once all the gas is worked out of it either by flux coatings or by manipulation, the better it is. Also when peening manganese, all welders would rather peen a weld without any coating on it and, besides, bare rod cost is $160 per ton less than coated electrodes. Use the coated electrode in the crack and use bare for subsequent layers.

Peening and Tooth Welding

When attaching wedge bars to worn teeth, the first pass is put in with a coated manganese (because it cuts easily) and if the welding is done partly vertical, a very heavy pass can be put in on the first pass; on small and

Table 1—Retreading Worn-out Grousers

The tables below indicate the number of feet of special applicator bars necessary to buy when retreading worn-out grousers, when cutting 1 in. shorter than grousers.

It is easier to apply bars cut from 1 to $1^1/_2$ in. shorter, as ends of grousers are worn round.

Models		No. of Grousers	8 In.	12 In.	13 In.	14 In.	15 In.	16 In.	18 In.	20 In.	22 In.	24 In.
International												
T-6	TD-6	64		59 ft.		70 ft.		81 ft.	91 ft.	102 ft.		
T-9	TD-9	66			67 ft.	72 ft.	78 ft.	83 ft.	94 ft.	105 ft.		
T-14	TD-14	72						90 ft.	102 ft.	114 ft.	126 ft.	
	TD-18	74							105 ft.	118 ft.	130 ft.	
Caterpillar												
	D-2	60		55 ft.	60 ft.			75 ft.				
	D-4	62				63 ft.		78 ft.	88 ft.	99 ft.		
	D-6	78						98 ft.	111 ft.	124 ft.		
	D-7	72							102 ft.	114 ft.	126 ft.	138 ft.
	D-8	76							108 ft.	120 ft.	130 ft.	145 ft.
Cletrac												
	AG	58		54 ft.		64 ft.		74 ft.				
	BD	60				65 ft.		75 ft.	85 ft.			
	BG	60				65 ft.		75 ft.	85 ft.			
	DD	62						78 ft.				
	CG	62						78 ft.	88 ft.	99 ft.		
	E	58	35 ft.		59 ft.							
	EN	58	35 ft.									
	EW	58	35 ft.		59 ft.							
	FD	68								109 ft.	120 ft.	131 ft.
	FG	68								109 ft.	120 ft.	131 ft.
Allis-Chalmers												
	HD-7	68							97 ft.	109 ft.	120 ft.	131 ft.
	HD-10	64							91 ft.	102 ft.	113 ft.	123 ft.
	HD-14	70							100 ft.	112 ft.	124 ft.	135 ft.
K	KO	68							97 ft.	109 ft.	120 ft.	131 ft.
L	LO	70							100 ft.	112 ft.	124 ft.	135 ft.
	M	62		57 ft.		68 ft.		78 ft.				
S	SO	64							91 ft.	102 ft.	113 ft.	123 ft.
Approx. oz. manganese electrodes per foot			8 oz.	10 oz.			15 oz.				20 oz.	
Size rod			$^3/_{16}$ in.	$^3/_{16}$–$^1/_4$ in.			$^1/_4$ in.				$^1/_4$ in.	
Size applicator bar			100	150			150 or 200				300	

One pass on each side with a bare or coated manganese electrode large enough to fill up V. No hammering necessary.

Applicator bars do not need to be kept cool. Use a large electrode, as speed is of great importance.

Although not necessary, it is helpful to position work so welding can be done slightly up hill.

Lb. rods used, vary. Figures approximate only.

Fig. 7—Corner Blade for a Bulldozer with a $^5/_8$-In. Strip of Manganese 2 In. Wide Welded On

medium teeth no peening is usually necessary but on succeeding passes it is usually best to deposit only half of one rod and peen hard with a hammer ground to the proper shape so it is not sharp enough to cut the weld but narrow enough to go down into the vee and forge the weld. Peen hard while hot—red-hot, if possible.

Wedge bars and many teeth must be kept cool (below 660° F.) as their physical properties are slightly different from flat and round bars and it is necessary to skip from one tooth to another working on four if small or two or three if larger teeth. Do not put the wedge bar closer than $^1/_8$ in. to the tooth after cutting the rounded point off the tooth and re-pointing it so as to be able to get to the bottom of the vee and allow one weld to go right down and fuse into the weld on the other side. Always use a bar thick enough to make the tooth thicker than when it comes in to you; in other words, make it as thick as it was, before even being used, then the bar will not bend or break.

It is generally not necessary to peen the welds when attaching flat bars to carbon-steel buckets, but of course the welds have greater strength when peened. Tack both sides down, then weld a few inches and skip a few inches, welding in the places skipped later.

Manganese bars should be welded to any kind of steel—low-carbon, high-carbon, chrome-nickel or manganese—by using the coated manganese for the first pass, as coated manganese is the most ideal material for welding dissimilar metals and it is the latest and most up-to-date method.

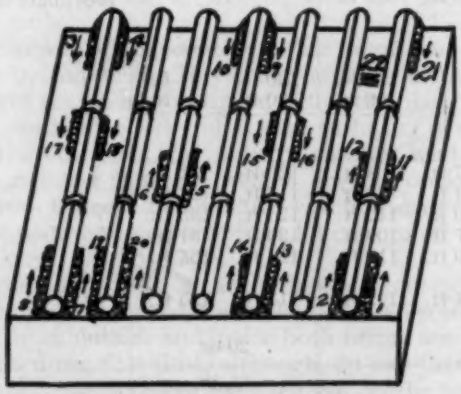

Fig. 8—Short Bars on Crusher Plate

Bulldozer Corner Blades

Many contractors have found it very advantageous to repair worn bulldozer blades by using manganese bars usually $^5/_8$ in. thick and 2 in. wide and welding this strip on as shown in Fig. 7. This repaired corner blade will last more than twice as long as a new corner blade, made of the usual high-carbon steel, if used where it gets considerable impact. Coated manganese electrodes are used to attach the manganese to the high-carbon steel.

Crusher Jaws

In repairing crusher jaws it is important to eliminate warping them if they are to be bolted in place when again used, but if babbitted in place it does not matter.

Some have submerged the back of plates in cold water while welding the front and this results in a greater difference in temperature of the front and back, causing still greater warpage than if not put in water at all. Heating the back the same amount as the front does eliminate all the warpage, but the problem of keeping the whole plate below 660° F. this way is difficult. It is an expensive method and too hot a place to work in the summertime although successful jobs have been done this way.

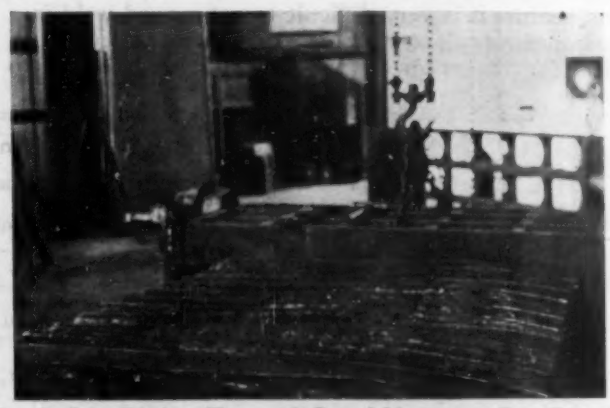

Fig. 9—Jaw Crusher Plate with Round Manganese Bars Cut in 3 Lengths Welded on Where Worn Down

A method which is easy and simple is to weld the back of two plates together (if the plates are thin) or weld a couple of channel irons or railroad rails onto the back to hold the ends down while welding, then cut your round manganese bars in three lengths as shown in Fig. 8, leaving one end of the bar untacked and weld from one end along each side which will make the bar grow in length. Only a few inches should be welded at a time, skipping to another place as the round bar will lengthen until it touches the bar at its end which is tacked on about $^5/_{16}$ in. away from its end, and when allowed to cool will pull back away again, being able to breathe. After this process is continued until the job is finished, the whole plate is allowed to cool and the ends of these bars are welded together.

As in other applications of round bars described previously the bars should be up $^1/_8$ in. or more according to their size so a weld can be made clear under to meet the weld on the other side.

It is easier to weld under round bars in a narrow place with a coated electrode, which will help remove the gas in the manganese as it is hard to manipulate a bare rod enough to remove all the gas in such a place.

If there are hollows at each end of the plate it usually is necessary to deposit some manganese where the bar is

going to be laid, before applying the round bar so as to have a level place to lay the round bar. Sometimes a smaller diameter round bar is used across the center of the plate than those used at each end where the wear has been more severe.

Peening should be done after a weld has been made on both sides of a round bar for a few inches causing the round to become red-hot, at which time very hard blows should be struck directly on top of the round bar instead of trying to hit the welds.

Gyratory Crushers

Welding concaves and mantles on gyratory crushing equipment is not considered a difficult job but much time can be saved by the use of applicator bars.

Sometimes these bars are run in a circle or around the circumference of the mantle just far enough apart so welding can be done in between and filled up level with the welding. These bars can be cut in lengths reaching one-third way around and the welding started in the center going each way hammering the bar down as you go around or, better yet, the bars had better be rolled to about the same circle as the mantle beforehand, especially if large bars such as 1 in. are necessary to use as it saves a lot of hard work.

Some jobs have been done by rolling one length in a circle to reach all the way round on small crushers and satisfactory results have been obtained.

The bars will be several different sizes as the amount of wear varies on the crusher, and parts worn a little will

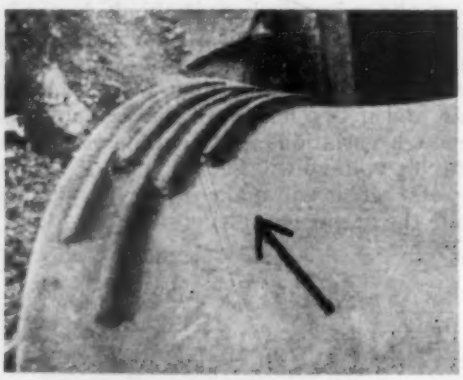

Fig. 10—Applicator Bars Attached, Ready for Filling in by Use of Manganal Welding Electrodes

have a small diameter round bar applied to bring it to the proper build-up, while next to it the next larger size bar will be just the right size. The size to order for the job can be determined by making a template or using a straight edge and measuring how much build-up is needed every few inches.

On some jobs round bars are used laying them lengthwise over the part worn, tapering the end of the bar so it is thinner at the point where not much wear has taken place.

The first pass only should be welded with coated manganese and after the bars have been attached, a bare rod is cheaper and just as satisfactory.

Enough peening to prevent cracks should be done but it is not practical to peen manganese by hand or with an air hammer every few seconds on layer after layer for the purpose of work hardening the manganese because, in the first place, the next layer of welding you put on melts down the part you work hardened and covering it with hot metal causes it to be annealed or softened anyway,

Fig. 11—Close-Up of Round Applicator Bars Attached to Gyratory Crusher Mantle. Note Bars Forged Flat at End Before Attaching

and the amount of hardness obtained is not worth the amount of labor cost involved. It is necessary to protect manganese on many jobs from initial wear until it gets a chance to work harden and the cheapest way to do this is to lay as thin a layer as possible of a low-priced, hard-surfacing electrode over the top which will give at least 400 Brinell hardness, and by the time that is worn off the manganese will be work hardened if there is considerable impact.

Cement and lime-crushing plants usually have a crusher that requires ridges to be built up and no building up in between, and the round applicator bars are applied and then a thin layer of hard surfacing is put over the top.

Dump Truck Bodies

Many trucks used in hauling stone or other hard material require repairs to the bottoms and sometimes soft steel is used; but when manganese plates or bars are used, the pieces can be one-half the thickness and weight and still have the same strength and better wearing qualities, keeping the pay load high and saving tire wear and engine repairs, besides lasting longer.

Railroad Frogs and Crossings

Applicator bars are being used more and more by large railroads in the form of round and triangular bars when a lot of building up must be done repairing a cracked piece of trackwork. Where there is plenty of room the triangle bar is put in with the point down so welds go in under and meet underneath and half of

Fig. 12—Round Applicator Bars Welded on to a Roll Crusher as Used in Cement Mills

the heat goes into the round bar and half into the trackwork; the heat is dissipated faster into the air and much less welding is done and no warping of the trackwork follows the welding as is often the case otherwise.

Coated manganese is being used by many for the first pass and after that bare manganese nickel steel electrodes the rest of the way, with a helper hammering very quickly after the welder breaks the arc, starting the hammering where the arc was started and gradually hammering over to the part where the arc was broken, so the metal just deposited is not white-hot but red before hammering.

It is very important to have electrodes free from scale and dirt on this work as this can be peened down into the weld and so much foreign matter accumulates during successive layers that pinholes develop. Some manufacturers have sent out electrodes in a condition which makes it necessary for the railroad welder to sand blast the rods before using them.

Some railroads have rules and regulations that no flame cutting can be done on the work of cutting out to the bottom of the cracks and require all grinding, but others allow flame cutting a little at a time, being careful not to heat up the work unnecessarily and allowing to cool down well before beginning welding. Both methods appear to produce satisfactory results.

One thing to bear in mind is that aside from expansion and contraction troubles, the heat treatment in Hadfield manganese will not be disturbed at heats as low as most people think, and according to John Howe Hall, page 568, *American Society for Metals Handbook*, 1939 edition, "If the heat-treated steel were to be reheated for a long time at 660° F. or for a shorter time at or above 750° F., it would become exceedingly brittle due to the liberation of carbide and the partial transformation of the Austinite." Therefore, if cutting is done in frog work some grinding should be done to grind away the part heated to above 750° and at the same time remove slag, etc., and only a little cutting done at a time before allowing to cool.

The welding must not be worked at continuously or too much expansion will result, as Mn, like 18 Cr–8% Ni, expands 50% more than pure iron.

From the above it can be seen that by using manganese nickel steel applicator bars the work is done very often three times as fast, the cost of applicator bars is less than the cost of electrodes, you keep the heat down lower at the place where repairs are being made resulting in less shrinkage strains and greater strength. Now many jobs that were not worth repairing by welding by the drop-by-drop method, depositing 3 or 4 lb. of manganese per hour, can now be done as one can deposit from 8 to 10 lb. per hour using applicator bars, making the cost of repairing much below the cost of new parts.

Voltage

When welding with manganese electrodes it is necessary to have the open circuit voltage high. If one has large size cables, and the proper size connectors and is not working far away from the machine, the voltage should be 75 to 80 open circuit for good results, if the cables are too small and connections are under size it is often necessary to have above 80 volts at the machine to have what is necessary at the work, or if the machine will not deliver more (some makes will not) it is necessary to use a short cable or change to the proper size cable and connections.

A machine will work fine on a low carbon steel shield arc electrode with voltage too low, small cables engine running to slow etc. but when one starts running manganese all these things must be corrected before you can start, otherwise you will have the amperage turned up too high in order to maintain an arc and the results will be very poor.

Manganese has about 20,000 psi. lower tensile strength when cast at too high a temperature, so have the speed of the machine up to rpm. marked on the generator which will keep the voltage where it should be, and whenever possible keep the voltage or rheostat control, on two control machines, turned over halfway up. Sometimes this is possible on the old machines which had only 3-amp. settings, and if two machines are available, use the one with enough variations on the amperes so at least 75 v. open circuit voltage will be available on electric- or gas-driven sets. This will make it very easy to maintain an arc while the amperage settings are fairly low.

(*Continued from page 952*)

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Coordination of Engineering and Production in the Manufacture of Welded Products*

By E. C. Brekelbaum†

ALL of us who are connected with the welding field in some form or other appreciate the great advantages that welding has to offer, and I think the time is long past in which welded construction has to prove or sell itself. At the same time, most of us realize that welded construction and fabrication present some new problems from the standpoint of Engineering and Manufacturing Methods and Controls.

* Scheduled for Twenty-Seventh Annual Meeting, A.W.S., Atlantic City, N. J., week of Nov. 17, 1946.

† Executive Chief Engr., Harnischfeger Corp., Milwaukee, Wis.

At the last Annual A.W.S. Convention the author presented a paper on "Production Problems and Production Control," and in that paper outlined a control system used by the Harnischfeger Corp. for the shop production and procedure control of its varied welded products.

In this paper the problems of coordinating engineering designs with the Production Shop will be discussed.

With the tremendous progress that welding and welded fabrication have made in the past five years, progress in the engineering of welded designs, proper drawings and engineering instructions have to keep pace. The days of designating a welding drawing with "Weld to Suit" or other general instructions, or no instructions, should definitely be past. In riveted construction, the predecessor of welded design, the engineer would never have thought of marking a drawing "Rivet to Suit." Weld sizes and joint preparations are an engineering problem just as rivet size and spacing have always been considered an engineering problem.

In analyzing the problem of proper engineering of welded parts, and coordina-

DATA SHEET

Plug Welds

Thick. of Material	Plug Dia.	Theo. Wt. of Plug in Lbs.	Fillet Size	Lbs. Per Ft.	Fillet Size	Lbs. Per Ft.
3/16	9/16	.0137	3/16	.0659	1/2	.4669
1/4	9/16	.0175	7/32	.0894	9/16	.5915
5/16	11/16	.0262	1/4	.1169	5/8	.7301
3/8	13/16	.0550	9/32	.1469	11/16	.8801
7/16	15/16	.0853	5/16	.1823	3/4	1.05
1/2	1-1/16	.125	11/32	.2196	13/16	1.20
5/8	1-1/16	.157	3/8	.2615	7/8	1.42
3/4	1-1/16	.182	13/32	.3056	15/16	1.64
7/8	1-1/16	.219	7/16	.3255	1	1.70
1	1-1/16	.249	15/32	.4160		

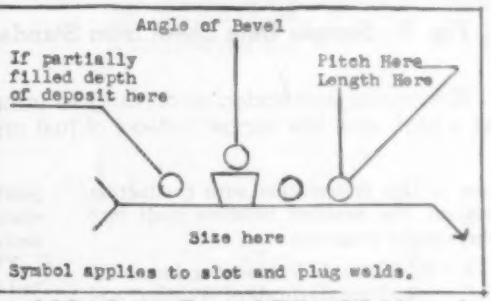


Fig. 1—Sample Data Sheet from Standards Book Showing Pounds of Metal per Foot of Fillet Weld, and Pounds per Plug Weld for Different Sizes of Plugs

Sheet also shows detail of A.W.S. symbol for plug welds, which has some modification over the standard A.W.S. symbol.

Size of Plug	Theo. Wt. per Plug, Lb.	Rod Size and Amp.	Act. Wt. Dep., Lb.	% Diff. + or −	Theo. Arc Time in Hr. per Plug	Act. Arc Time in Hr. per Plug	% Act. Theo. + or −
3/8 x 13/16	0.055	1/4-A-270	0.046	16−	0.009	0.0088	2.2−
3/8 x 13/16	0.055	1/4-B-290	0.056	1.8−	0.0078	0.0083	6.4−
3/8 x 13/16	0.055	1/4-P-300	0.051	7.3−	0.0083	0.008	3.5−
7/16 x 11/16	0.085	1/4-A-270	0.072	15−	0.014	0.0133	5−
7/16 x 11/16	0.085	1/4-B-290	0.074	13−	0.0129	0.0115	11−
7/16 x 11/16	0.085	1/4-P-300	0.080	5.9−	0.0128	0.012	6.3−
1/2 x 1 1/16	0.125	5/16-A-330	0.113	9.6−	0.0152	0.014	8−
1/2 x 1 1/16	0.125	5/16-B-380	0.125		0.0147	0.014	4.8−
5/8 x 1 1/16	0.157	5/16-A-330	0.144	8.3−	0.019	0.018	5.5−
5/8 x 1 1/16	0.157	5/16-B-380	0.141	10−	0.0185	0.0167	10−
3/4 x 1 1/16	0.187	5/16-A-330	0.164	12−	0.0228	0.0218	4.4−
3/4 x 1 1/16	0.187	5/16-B-380	0.169	10−	0.2020	0.0218	7
7/8 x 1 1/16	0.219	5/16-A-330	0.215	1.8−	0.0267	0.0288	7.9+
7/8 x 1 1/16	0.219	5/16-B-380	0.215	1.8−	0.0258	0.0242	6.5−
1 x 1 1/16	0.249	5/16-A-330	0.262	5.2	0.030	0.0293	2.3−
1 x 1 1/16	0.249	5/16-B-380	0.244	2.1−	0.0292	0.0270	7.5−

Fig. 2—Sample Data Sheet from Standards Book Showing Complete Information on Plug Welds of Definite Dimensions

Note the theoretical and actual weight of weld metal, and theoretical and actual arc time.

Rod Size	Rod Type	Deposit Rate of Electrodes — Lb. Deposited per Hr. — Amp. High	Lb./Hr.	Amp. Low	Lb./Hr.	Eff. % — High	Low	Arc Time per Inch of Electrode in Min. — High	Low
5/32	A	160	2.850	100	2.400	73.0	80.0	0.0980	0.1240
3/16	A	170	3.600	140	3.250	77.0	82.0	0.1200	0.1360
7/32	A	210	4.950	180	4.400	78.0	79.0	0.1120	0.1170
1/4	A	250	5.950	200	5.200	76.0	79.0	0.1340	0.1520
5/16	A	310	8.100	270	7.500	78.0	80.5	0.1520	0.1680
5/32	B	180	3.3	125	2.6	68.0	72.0	0.0820	0.1080
3/16	B	190	3.8	160	3.4	74.0	78.0	0.1090	0.1240
7/32	B								
1/4	B	270	6.1	220	5.4	75.0	77.0	0.1220	0.1480
5/16	B	350	8.1	320	7.6	76	79	0.1440	0.1580
5/32	P	170	3.400	130	2.800	77.0	79.0	0.0960	0.1180
3/16	P	200	4.100	170	3.600	77.5	81.0	0.1140	0.1300
7/32	P	230	5.400	190	4.800	76.0	79.0	0.1080	0.1220
1/4	P	290	6.600	230	5.700	75.0	79.0	0.1200	0.1420
5/16	P	400		340					
5/32	Q	175	3.700	130	3.000	75.0	78.5	0.0800	0.1020
3/16	Q	200	4.300	170	3.800	74.0	77.0	0.1000	0.1200
7/32	Q								
1/4	Q	300	6.500	250	5.500	72.0	73.0	0.1160	0.1400
5/16	Q	400		350					
5/32	F	170	...	130					
3/16	F	200	...	170					
7/32	F	230	...	190		Same as for rod P			
1/4	F	290	...	230					
5/16	F	400	...	340					
5/32	D	180	3.300	130	2.500	62.0	61.5	0.0740	0.1040
3/16	D	210	4.700	180	3.800	65.0	66.0	0.0880	0.0980
7/32	D								
1/4	D	320	7.500	240	6.300	65.0	70.0	0.0940	0.1200
5/16	D	420	11.000	350	9.200	70.0	71.5	0.1100	0.1270
						Does not include stub loss			

Fig. 3—Sample Data Sheet from Standards Book Showing Complete Information on All Types of Welding Electrodes

Electrodes are coded according to information in Fig. 7. Amperes, deposition rate and arc time are given as a high and low range instead of just one figure.

tion of this information with production control, the problem resolves itself into three major programs:

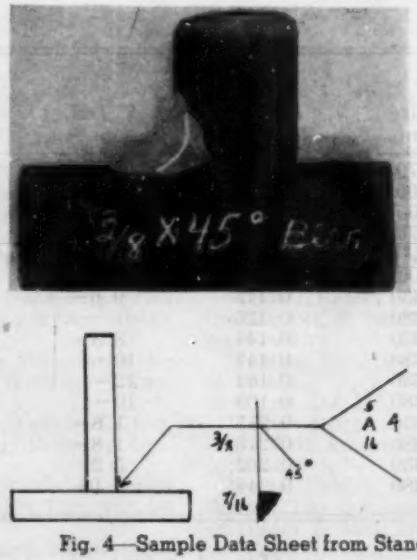
1. Education of Engineering Personnel in Fundamentals of Welding, and in Its Production and Control Problems.
2. Adoption of a Suitable Standard System of Welding Symbols (A.W.S. Symbols) for Explicit and Detailed Designation of Welds and Weld Preparations on Engineering Drawings.
3. Coordination of Engineering Drawings with Shop Procedure Instructions to See That Engineering Specifications Are Actually Met in Production.

1. Education of Engineering Personnel in Fundamentals of Welding, and in Its Production and Control Problems

Too many engineers today still do not have a good enough understanding of the welding process and its production and control problems to appreciate their responsibility and part they play in the successful execution of a welded product. It should be a challenge to the welding personnel in every company to exert every effort to make all information on welding, welding cost, welding procedure and welding control available to their respective engineering departments so as to enable them to get a better understanding of the problems involved and help them in setting up the proper methods of designating joint preparations and weld types and sizes on the drawings, and to make their designs most economical.

There is not enough time to go into detail on the plan followed in our company to fulfill this part of the program. The welding personnel in our company prepared an extensive Shop Standards book on Joint Preparations, Procedures, Controls and Costs of all types of welded joints. This book was turned over to the Engineering Department to aid them in setting up standards on welding joints and their preparations .Some sample sheets from this

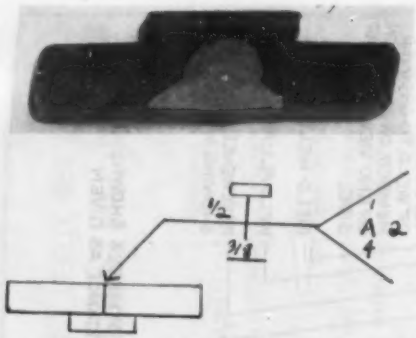
RATE AND STANDARD SHEET FOR WELDED JOINTS



Type of Weld: 4
Detail of Weld and Symbol
Recommended Use of Weld: Heavy sections to develop full strength
Type of Electrode: A
Alternates
Rod Sizes: 5/16
Amperes: 300
Number of passes and sequence: 2. Chip after first pass
Arc time per foot of weld and per foot of rod
0.0690 1.88
Remarks: Maximum penetration essential. First pass should be heavy enough to prevent cracking.

Fig. 4—Sample Data Sheet from Standards Book Showing a Type 4 Fillet Weld

Weld is coded according to information in Fig. 7. Symbol and picture of actual cross section of weld and other pertinent information is given. There is a total of 84 sheets of different fillet welds made under different conditions. These sheets cover all fillet welds used, or contemplated to be used in our shop.



Type of Weld: 2
Detail of Weld and Symbol
Recommended Use of Weld: For complete root penetration
Type of Electrode: A
Alternates
Rod Sizes: 1/4
Amperes: 240
Number of passes and sequence: 3. Clean between passes
Arc time per foot of weld and per foot of rod
0.102 1.62
Remarks: Care must be exercised to penetrate into backup. Do not undercut on first pass and clean between passes.

Fig. 5—Sample Data Sheet from Standards Book Showing a Type 2 Butt Weld

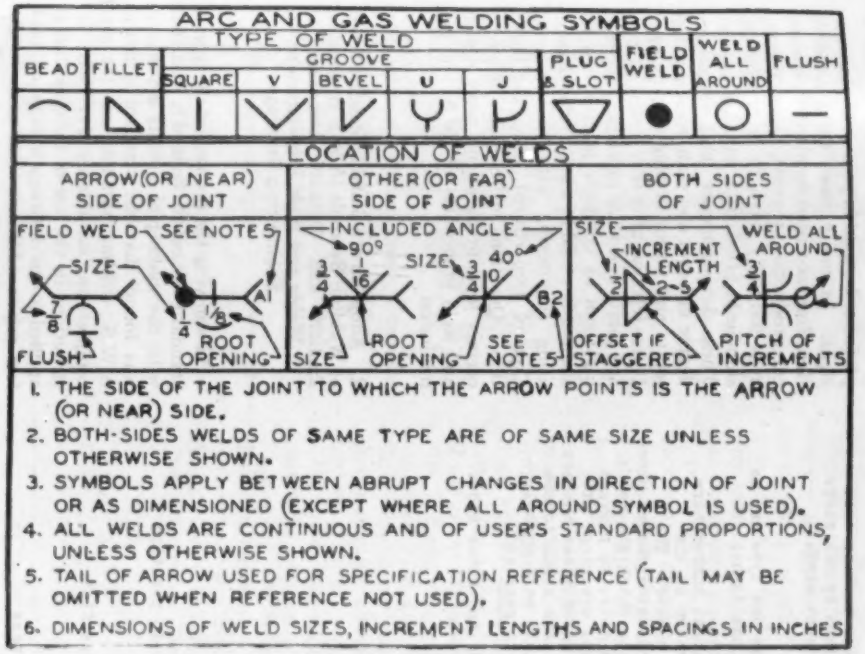
Weld is coded according to information in Fig. 7. Weld symbol, picture of weld cross section and other pertinent information is given. There is a total of 43 sheets of different butt welds made under different conditions. These sheets cover all butt welds used, or contemplated to be used in our shop.

Thickness of Mat.	Theo. Wt. of weld in lbs. per ft.	Actual wt. of weld in lbs. ft.	% diff. + or −	Theo. arc time in hrs. per ft.	Actual Arc time in hrs. per ft.	% diff. + or −	Ref. sheet
1/2	.557	.433	22−	.103	.091	11−	10B6
1/2	.576	.552	4.3−	.099	.110	.11 +	27B5
1/2	.635	.588	7.4−	.107	.102	4.7−	2B3
1/2	.635	.551	13.2−	.109	.102	6.4−	9B3
1/2	.850	.804	5.4−	.110	.118	7.3 +	12B1

Note: -% difference between theo. & act. figured on theo.

Fig. 6—Sample Data Sheet from Standards Book Showing Butt Weld Tabulation for Different Thicknesses of Plate

Note the theoretical and actual weight of weld metal, and the theoretical and actual arc time. There is a total of 9 sheets of these tabulations.


ARC AND GAS WELDING SYMBOLS
TYPE OF WELD
BEAD
FILLET
GROOVE
SQUARE
V
BEVEL
U
J
PLUG & SLOT
FIELD WELD
WELD ALL AROUND
FLUSH
LOCATION OF WELDS
ARROW (OR NEAR) SIDE OF JOINT
OTHER (OR FAR) SIDE OF JOINT
BOTH SIDES OF JOINT
FIELD WELD
SEE NOTE 5
SIZE
FLUSH
ROOT OPENING
INCLUDED ANGLE
90°
40°
SIZE
ROOT OPENING
SEE NOTE 5
SIZE
INCREMENT LENGTH
WELD ALL AROUND
OFFSET IF STAGGERED
PITCH OF INCREMENTS
1. THE SIDE OF THE JOINT TO WHICH THE ARROW POINTS IS THE ARROW (OR NEAR) SIDE.
2. BOTH-SIDES WELDS OF SAME TYPE ARE OF SAME SIZE UNLESS OTHERWISE SHOWN.
3. SYMBOLS APPLY BETWEEN ABRUPT CHANGES IN DIRECTION OF JOINT OR AS DIMENSIONED (EXCEPT WHERE ALL AROUND SYMBOL IS USED).
4. ALL WELDS ARE CONTINUOUS AND OF USER'S STANDARD PROPORTIONS, UNLESS OTHERWISE SHOWN.
5. TAIL OF ARROW USED FOR SPECIFICATION REFERENCE (TAIL MAY BE OMITTED WHEN REFERENCE NOT USED).
6. DIMENSIONS OF WELD SIZES, INCREMENT LENGTHS AND SPACINGS IN INCHES

Perpendicular Leg of Weld Always Drawn to Left.

To Supplement the Standard Symbols to Emphasize and Stress the Importance of an Area Not to Be Welded, Use the Following Symbols. If Necessary Mark Length on Top of Line. Hatch Mark if No Weld Area Breaks Continuity of Weld, and to Designate Exact Area.

SPECIFICATION REFERENCES
(Use in Tail of Arrow)

TYPE OF WELD	FINISH MARKS	ELECTRODES
1. Flat Single Pass	C− Chip	A − A.P. E-6010
2. Flat Mult. Pass	G− Grind	P − P.F. E-6012
3. Position Single Pass	Preheat Symbol □	F − F.W. E-6020
4. Position Mult. Pass		D − D.H. 2E-6020
5. Vertical		C − C.M.50 E-7020
6. Overhead		B − A.C.1 E-6011
7. Tack		Q − A.C.3 E-6013
8. Weld in Set Up		R − A.W.3 Type 307
		S − 2520− Type 310
		H − Harcote
		W− A.W.2C E-10020
		X − A.W.4 E-10012

Fig. 7—Sample Data Sheet from Standards Book Showing Legend Sheet for A.W.S. Welding Symbols

Included are our own supplements to the A.W.S. symbols and our code for Shop Procedure Specification References used in the tail of the arrow of the A.W.S. symbol.

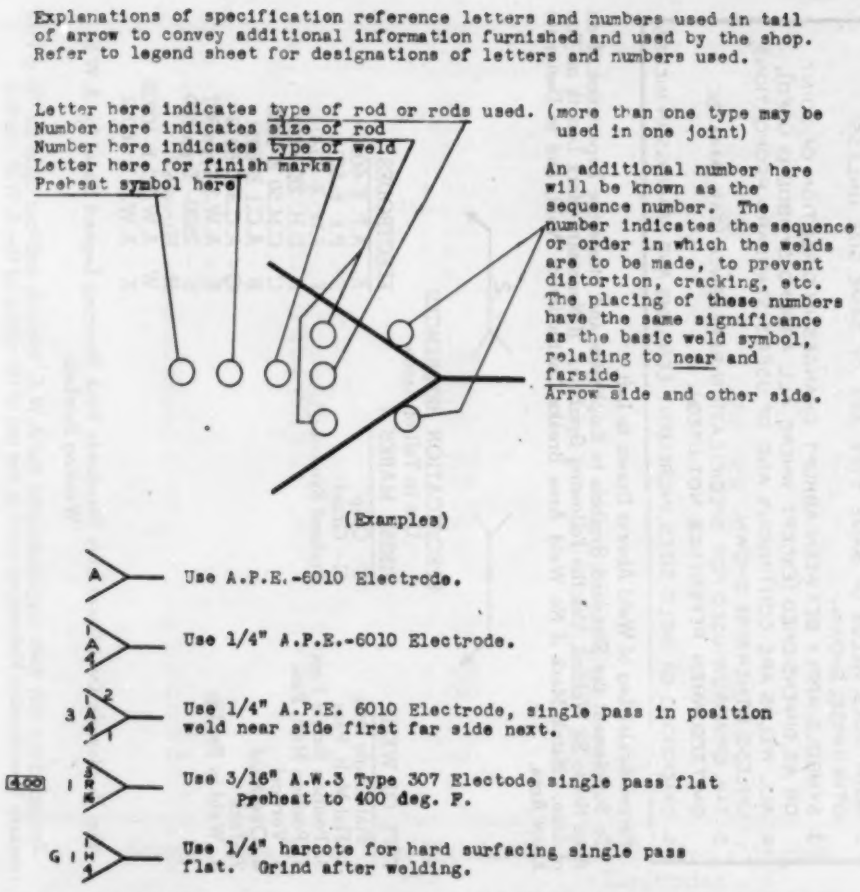

Explanations of specification reference letters and numbers used in tail of arrow to convey additional information furnished and used by the shop. Refer to legend sheet for designations of letters and numbers used.
Letter here indicates type of rod or rods used. (more than one type may be used in one joint)
Number here indicates size of rod
Number here indicates type of weld
Letter here for finish marks
Preheat symbol here
An additional number here will be known as the sequence number. The number indicates the sequence or order in which the welds are to be made, to prevent distortion, cracking, etc. The placing of these numbers have the same significance as the basic weld symbol, relating to near and farside
Arrow side and other side.
(Examples)
A
Use A.P.E.-6010 Electrode.
1/4 A
Use 1/4" A.P.E.-6010 Electrode.
3 2 1/4 A 1
Use 1/4" A.P.E. 6010 Electrode, single pass in position weld near side first far side next.
400 1 3/16 R S
Use 3/16" A.W.S Type 307 Electode single pass flat Preheat to 400 deg. F.
G 1 H
Use 1/4" harcote for hard surfacing single pass flat. Grind after welding.

Fig. 8—Sample Data Sheet from Standards Book Explaining the Shop Procedure Specification Reference in the Tail of the Arrow of the A.W.S. Symbol

Some examples are given to illustrate the code.

procedure book are shown in Figs. 1,2,3,4,5 and 6. This work was done very thoroughly, and all information was obtained by theoretical method and then checked by actual test. In all cases the difference between theoretical and actual figures is shown. Individual tests of all types of joints: butt, fillet, plug and slot welds in all sizes that are used or contemplated for use were made and tabulated as shown on sample sheet Fig. 4.

It is felt that this Shop Standards book will form the "Engineers' Bible" or handbook in guiding him toward sound economical design suited to the production methods and control established in our welding production divisions.

One of the primary reasons for preparing the Shop Welding Standards Book was to establish and verify all types of joint preparations and types of welds contemplated to be used in present and future designs. In many cases there are deviations from accepted standards for economical production reasons. General standards naturally have to be broader than standards fitted to a particular product. These deviations are most noticeable in degree of bevel and plate spacing on butt joints and varies in plug and slot welds. It was felt that after once setting up standard joints and their procedures and proving them by complete practical test, the standards would be a great help in coordinating engineering with the Production Control Department, Shop and Inspection. Questions of being able to execute certain joint preparations, types of welds and weld procedures should be kept to a minimum.

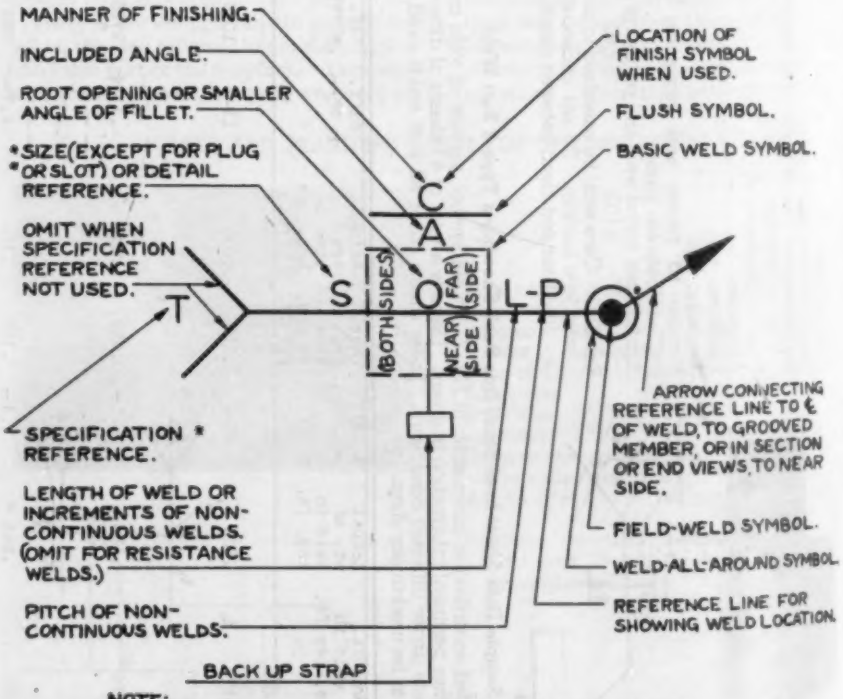

MANNER OF FINISHING.
INCLUDED ANGLE.
ROOT OPENING OR SMALLER ANGLE OF FILLET.
*SIZE(EXCEPT FOR PLUG OR SLOT) OR DETAIL REFERENCE.
OMIT WHEN SPECIFICATION REFERENCE NOT USED.
LOCATION OF FINISH SYMBOL WHEN USED.
FLUSH SYMBOL.
BASIC WELD SYMBOL.
C
A
S
O
L-P
T
BOTH SIDES
NEAR (FAR) SIDE
ARROW CONNECTING REFERENCE LINE TO ℄ OF WELD, TO GROOVED MEMBER, OR IN SECTION OR END VIEWS TO NEAR SIDE.
SPECIFICATION * REFERENCE.
LENGTH OF WELD OR INCREMENTS OF NON-CONTINUOUS WELDS. (OMIT FOR RESISTANCE WELDS.)
FIELD-WELD SYMBOL.
WELD-ALL-AROUND SYMBOL.
PITCH OF NON-CONTINUOUS WELDS.
REFERENCE LINE FOR SHOWING WELD LOCATION.
BACK UP STRAP
NOTE: RELATIVE POSITION OF DATA AND SYMBOLS SHOWN; NEAR, FAR AND BOTH SIDES SIGNIFICANCE AS GIVEN IN INSTRUCTIONS.

Fig. 9—Sample Data Sheet from Standards Book Giving the Standard Location of Information on A.W.S. Symbols

A.W.S. symbol modified to show back-up strap, and reference is made to additional information about symbols given in Figs. 1 and 8.

2. Adoption of a Suitable Standard System of Welding Symbols (A.W.S. Symbols) for Explicit and Detailed Designation of Welds and Weld Preparations on Engineering Drawings

In studying the problem of the types of standard symbols to be used in connection with the making of welding drawings, it was found that the standard system of A.W.S. welding symbols was the most complete and suitable set of symbols. Instructions in the use of these symbols as applied to our drawings were set up, and a few minor additions were made to take care of their applications to our particular problems.

There is no need of going into the details and use of the A.W.S. welding symbols be-

* See Fig. 8, Shop Specification sheet.
: See Fig. 1 Data Sheet.

cause the SOCIETY has published excellent information booklets. Several other booklets and papers have also been published, explaining the symbols and their uses in detail.*

3. Coordination of Engineering Drawings with Shop Procedure Instructions to See That Engineering Specifications Are Actually Met in Production

This third problem was by far the hardest problem to solve. The Production Department for years has tried different methods of setting up procedure controls on welded parts in accordance with engineering requirements. Under the heading of Procedure Controls we include the designation of type and size of weld rod, special welding procedures, such as preheating, chipping, etc., sequence of welding and position of weld.

All the first attempts were along the lines of drawing up procedure instructions, personal instructions by foremen or inspectors, or special marking of engineering prints for shop instructions by shop personnel.

All these attempts failed to some extent because the man works from the blue print and his instructions should be part of the print if at all possible. One of the hardest problems was to have the operator receive his instructions at the same time he received the prints. Another problem was to keep procedures up to date with any engineering changes that occurred on the engineering blue prints.

In trying to make procedure sheets on complicated drawings, we also found ourselves making duplications of drawings in the Shop Office in order to convey all information.

The final solution of these problems was to use the tail of the arrow of the A.W.S. symbol, which is reserved for specifications, and to work out a standard code for designating points of procedure in the tail of the arrow of the welding symbol. See Figs. 7, 8 and 9.

Figures 7, 8 and 9 show Instruction Sheets explaining the standard code for designating all phases of our procedure control.

We are in the midst of executing this part of the program. The plan is that the Engineering Department will finish its drawings, complete with A.W.S. welding symbols as to size and preparation of weld. An advance drawing will then go to the Shop Production Department for their usual rating and routing of the welded part. In the Production Department a welding specialist, acquainted with welding procedures and control in the shop and guided by the shop standards established, will complete the information in the tail of the arrow of the welding symbol and will return the advanced print with this information to the Engineering Department. A tracer in the Engineering Department will add this information on the tracing, so that the procedure information will always be a part of the engineering drawing. Any change in procedure will be handled by engineering change, just as any other change is handled on the drawing.

In closing, the author would like to point out that this program of proper engineering of welded parts and its coordination with shop procedure and control is a large program which will take several years in any good sized organization. At times the problems being confronted might discourage the individuals working on the project, but I am sure that the reward will be in the results and economies derived in the future.

If welded fabrication is to maintain its high place as a production tool and is to have its further rapid expansion, sound welding engineering and rigid engineering specifications on welding are a "MUST."

* "American Standard Graphical Symbols for Use on Drawings in Welding."

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THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

1946–47 OFFICERS AMERICAN WELDING SOCIETY

Since nominations other than proposed by the Nominating Committee were made by 25 qualified members, as prescribed by the By-Laws, Article IX, Sections 1 and 2, election circular and ballot were sent to the membership, under date of July 25th, stating the names of the candidates for the several offices falling vacant and the time for closure of the voting, which was August 29th at 1 o'clock in the afternoon. Accordingly, the following have been elected officers for the year to begin on the adjournment of the 1946 Annual Meeting. These officers will be declared elected at the Business Session of the Annual Meeting:

President, L. W. Delhi, Vice-President, Hunt, Mirk & Co., San Francisco, Calif.

First Vice-President, Harold O. Hill, Asst. Chief Engineer, Fabricated Steel Construction, Bethlehem Steel Co., Bethlehem, Pa.

Second Vice-President, G. N. Sieger, President and General Manager, S-M-S Corp., Detroit, Mich.

Directors at Large: D. H. Corey, Welding Engineer, The Detroit Edison Co., Detroit, Mich.; J. F. Maine, Chief Engineer, Republic Structural Iron Works Co., Cleveland, Ohio.; E. L Mathy, Exec. Vice-President, Victor Equipment Co., San Francisco, Calif.; Leslie S. McPhee, Welding Supt., Whiting Corp., Harvey, Ill.

As no independent nominations were received for Vice-Presidents of Districts Nos. 2, 4 and 6, the District Nominating Committees' candidates are declared elected, as follows:

District No. 2 (Mid-Eastern): Harry W. Pierce, Asst. to General Manager, New York Shipbuilding Corp., Camden, N. J. District No. 4 (Central): G. O. Hoglund, Engineer, The Aluminum Co. of America, New Kensington, Pa. District No. 6 (Mid-Southern): Howard N. Simms Metallurgist, Black, Sivalls & Bryson Inc., Oklahoma City, Okla.

ANNUAL MEETING
ATLANTIC CITY
NOV. 17—22

OUR NEW PRESIDENT

L. W. Delhi, prominent member of the AMERICAN WELDING SOCIETY on the coast, has been elected President of the AMERICAN WELDING SOCIETY for the year 1946–47.

Mr. Delhi was born in Arizona, November 1892, and is of Danish extraction. He attended Throop Polytechnic and U. S. C. Mr. Delhi was unable to complete his university work and turned to professional baseball for four years before resuming engineering with the Nevada Consolidated Copper Co., at Ray, Ariz., which position he held for four years. He then spent three years in engineering work and contracting in Southern California and about twenty years ago joined the Western Pipe & Steel Co. He is a member of the Olympic Club, Lakeside Golf & Country Club, Astronomical Society of the Pacific and the Seismological Society.

L. W. Delhi

Mr. Delhi has long been active in promoting the interests of the AMERICAN WELDING SOCIETY on the Pacific Coast, having served two years as Regional Vice-President and currently served as National Director of the AMERICAN WELDING SOCIETY. Mr. Delhi, having had much experience in the building and operation of a production organization with many and varied labor problems, was recently drafted to serve as president of the California Metal Trades Association. This organization represents more than 350 central California metal trades firms employing approximately 26,000 men.

About the beginning of this year, Mr. Delhi joined the firm of Hunt, Mirk and Co., 141 Second St., San Francisco, a pioneer Bay Area firm of engineers and contractors of more than 40 years' experience in their line, thus concluding 22 years of service in the management of the Western Pipe and Steel Co. of California, This company was recently purchased by the Consolidated Steel Corp. of Los Angeles. Mr. Delhi was vice-president in charge of shipbuilding operations, which started at the beginning of the Maritime Commission program in 1939. The program consisted of the design and construction of more than 48 special all-welded C3-type vessels for the United States Maritime Commission, practically all of which were converted into specialized vessels for Army and Navy use.

The program also involved the fabrication of many thousands of tons of steel for other firms, as well as a comprehensive program of ship repair work for the Navy and War Shipping Administration.

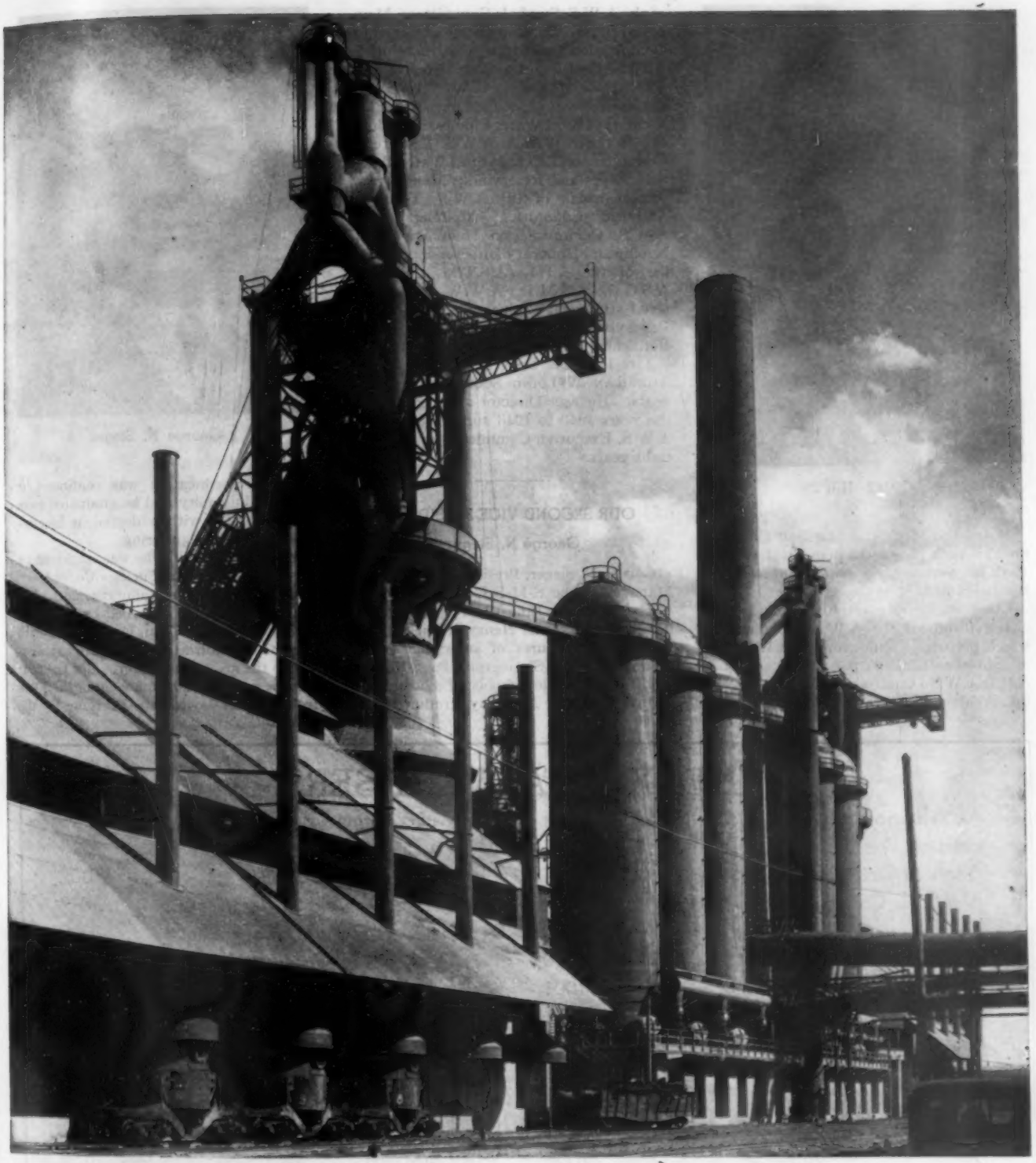
Mr. Delhi has been one of the outstanding proponents of the use of automatic arc welding, not only in the construction of ships, but also in boiler drums, pen stocks, oil refinery equipment and other quality plate work, and has been particularly active in the development and use of automatic electric arc welding.

The AMERICAN WELDING SOCIETY is indeed fortunate to get a man of Mr. Delhi's broad experience and wide industrial contacts to head up its activities for a one-year period. Mr. Delhi is the first member from the Pacific coast to serve as President.

OUR FIRST VICE-PRESIDENT

Harold O. Hill is Assistant Chief Engineer, Fabricated Steel Construction, of the Bethlehem Steel Co. at Bethlehem, Pa. Born in Ontario, Canada, he was educated at the University of Toronto, from which he received the degree of B.A.Sc. in Mechanical Engineering.

He commenced his engineering career with the Riter-Conley Co. of Pittsburgh, Pa. Here he served in many capacities and was Chief Engineer when this company was merged into McClintic-Marshall Co. He became Assistant Chief Engineer of the enlarged company in charge of the engineering on tank and platework.



Welded Steel Plate Work

During the last two decades we have utilized the latest developments in welding in the construction of complicated plate work. The above view shows one of the three giant blast furnaces we fabricated and erected for a steel mill in Utah. They are of welded construction.

CHICAGO BRIDGE & IRON COMPANY

Chicago 4.....2455 McCormick Bldg.	Birmingham 1.....1907 North 50th Street	Washington 4.....703 Atlantic Bldg.
New York 6.....3398—165 Broadway Bldg.	Tulsa 3.....1654 Hunt Bldg.	Philadelphia 3.....1668–1700 Walnut Street
Cleveland 15.....2282 Guildhall Bldg.	Atlanta 3.....2186 Healey Bldg.	Los Angeles 14.....1471 Wm. Fox Bldg.
Detroit 26.....1556 Lafayette Bldg.	Houston 1.....5624 Clinton Drive	San Francisco 11 .1297–22 Battery Street Bldg.

Fabricating plants in CHICAGO, BIRMINGHAM; and GREENVILLE, PA.

H. O. Hill

When the McClintic-Marshall Co. was merged with the Bethlehem Steel Co. in 1931 he continued his same duties with the Bethlehem Steel Co.

Other engineering activities include the chairmanship of the A.W.S. Committee, which prepared "Rules for Field Welding of Storage Tanks;" Chairman of the A.P.I.-A.W.S. Conference Committee on the Welding of Storage Tanks; Member of the A.W.S. Symbols Committee; Member of the A.W.S. Committee on Standard Qualification Procedure; Chairman of the A.W.S. Coordinating Committee on Research; Member of the A.W.S.-A.W.W.A. Committee on Specifications for Field Welding of Steel Water Pipe Joints; Member of the A.W.W.A.-A.W.S. Conference Committee on Elevated Steel Water Tanks Standpipes and Reservoirs; Member and past-chairman of the A.W.S. Technical Activities Committee; Member of the A.W.S. Committee on Honorary Membership and Honorary Directorship; Member of the A.P.I., A.S.T.M., A.I.E.E., A.S.C.E., A.S.M.E., A.W.W.A., a registered structural engineer in the State of Pennsylvania and past-president of the Bethlehem Rotary Club.

Mr. Hill has been a member of the AMERICAN WELDING SOCIETY for fifteen years. He was Director-at-Large during the years 1940 to 1943 and served on the A.W.S. Executive Committee for the past eight years.

OUR SECOND VICE-PRESIDENT

George N. Sieger

George N. Sieger, President and General Manager of the S-M-S Corp. of Detroit, Mich., was born June 19, 1889, in Bethlehem, Pa., the son of Henry N. Sieger who was a manufacturer of snowguards and roofing slate in Slatington, Pa. He attended the public schools of Slatington, and Mercersburg Academy, graduating in 1908. His education was continued at Lehigh University and he graduated from there in 1912 with a degree in Electro-Metallurgical Engineering.

George N. Sieger

From 1912 to 1914 he was employed by the Continuous Zinc Furnace Co. of Hartford, Conn., as a metallurgist, and when that company was absorbed by the Commercial Research Corp. he remained with the latter organization until 1916 as assistant to the general manager. For the next year he was assistant manager of the Electrolytic Oxy-Hydrogen Division of the

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Banish "Speed Limits" From The Road to PRODUCTION—use Federal Resistance Welders

THIS BOOK ANALYZING BASIC TYPES OF FEDERAL AUTOMATIC WELDERS AND THEIR APPLICATION IS YOURS ON REQUEST

FOR SPECIAL DELIVERY
Current production permits early shipments on these models
PA 1 Press Type Welders
Rocker Arm Spot Welders
Subject to prior order

Many of the limitations imposed on production speed in the metal working industries are avoidable.

The fact is that material shortages and unit-man-hour problems beyond our control make it more imperative than ever to do away with limitations that are more or less self-imposed. Specifically, failure to employ methods of maximum efficiency.

Automatic welding has made possible more short cuts in time and cost in metal goods manufacture than any one method or "tool" we know. Wherever metal to metal fastening on a production basis is a problem, there's a strong chance of resistance welders of one type or another providing the most efficient answer. Federal makes every type and size of resistance welder, many specially designed for highly special needs.

Motive behind the great National Metal Congress show at Atlantic City is to provide a refresher course on the most modern and efficient methods for speeding production. Federal will be there with a big demonstration pertinent to this point. (Exhibit F 125, Main Floor) . . . A wonderful chance for you to get authoritative advice on methods banishing speed limitations.

Meantime there's a Federal representative in every key city ready to give you such advice immediately. There's also bulletin SP 346 (illustrated herewith) which describes the vast variety of basic types of Federal Resistance Welders and their application. *Get your copy now!*

THE Federal MACHINE AND WELDER COMPANY

SUBSIDIARIES
Sommer and Adams Co., Cleveland—SPECIAL HIGH PRECISION MACHINES
The Warren City Mfg. Co., Warren—WARCO PRESSES and PRESS BRAKES

MEMBER RWMA

206 DANA ST., WARREN, OHIO

Davis Bournonville Co. of Jersey City, N. J., leaving there to go into the service of his country. He was sent overseas where he remained for two years in charge of the production and distribution of non-toxic gas, attaining the rank of captain in the U. S. Army.

Following his release from service he went to Canada to become Managing Director of the Canadian Consolidated Corp. of St. Catharines, Ont., and remained there for five years. The next years were spent in the employ of P. R. Mallory & Co. of New York and Indianapolis, first with the Elkon Works where he became manager of that plant, and later as executive metallurgist, dividing his time between New York and Indianapolis. He served on the board of directors of this company and also found time to help organize the Carboloy Co., serving as technical assistant to the president.

In 1933 he left the Mallory Co. to organize the S-M-S (Specialized Metal Service) Corp., in Detroit, Mich., of which company he was elected President and General Manager and to which he has since devoted his exclusive time and attention.

Several patents in powdered metallurgy are credited to Mr. Sieger.

Mr. Sieger is a member of the AMERICAN WELDING SOCIETY, the Society of Automotive Engineers, American Society for Metals and The Engineering Society of Detroit; is on the Aircraft Welding Standards Committee of A.W.S. and was the first chairman of the Alloy Group of the Resistance Welder Manufacturers' Association. During World War II he served as a member of several Industry Advisory Committees to the Resistance Welding Section of the War Production Board and later on as consultant to the Tools Division of the War Production Board.

Mr. Sieger has been Secretary-Treasurer of the Detroit Section of the AMERICAN WELDING SOCIETY since 1941, is Chairman of the National Membership Committee and Past District Vice-President of the Society.

PRESSURE VESSEL RESEARCH

The Welding Research Council announces that its Pressure Vessel Research Committee has appointed Russell J. Love, formerly chief engineer, Southwest Welding and Manufacturing Co., Alhambra, Calif., as Executive Secretary of the Pressure Vessel Research Committee. The Committee has established its headquarters office at 30 Church St., New York 7, N. Y. Mr. Love moved from California to New York in July of this year to take charge of the new office.

Mr. Love has been engaged in pressure vessel work for many years. He is a graduate of California Institute of Technology, 1928. From 1928 through 1931, he was employed by C. F. Braun & Co. as a research engineer. In 1932, he joined Southwest Welding and Manufacturing Co., and was made Chief Engineer in 1936, and Assistant Vice-President in 1944. Mr. Love is the author of several papers on Pressure Vessels, X-ray Inspection and related subjects.

Russell J. Love

The Welding Research Council, founded in 1935 under the Engineering Foundation, is now sponsored by the AMERICAN WELDING SOCIETY, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers and American Society of Mechanical Engineers.

The Pressure Vessel Research Committee was organized in 1945, as an activity of the Welding Research Council, for the purpose of encouraging and conducting needed research in the Pressure Vessel field, and to act as a clearing-house and coordinating office for research information in the field. The Pressure Vessel Research Program includes consideration of: (1) Materials, (2) Design, (3) Fabrication and (4) Inspection and Testing. Definite research projects in the first three categories have already been started in several universities. The work is actively supported by both manufacturers and users of Pressure Vessels, on a nation-wide basis. The Pressure Vessel Research Committee membership includes representatives of insurance companies and of the code-making bodies, as well as fabricators and users, with increasing interest being shown by all concerned.

HIEMKE JOINS A. O. SMITH CORP.

Hugo Hiemke has joined the Pacific coast division of the A. O. Smith Corp. as assistant director of the company's service and development laboratory in Los Angeles. He will work on technical problems arising in the company's west coast plant and in the plants of two subsidiary concerns, the Sawyer Electrical Mfg. Co. and the Smith Meter Co.

For the last year he has been research supervisor for the war metallurgical committee of the National Research Council. For 11 years prior to that, he was with welding laboratory in Milwaukee from 1930 to 1934.

Mr. Hiemke is a graduate of the University of Wisconsin and is a member of the AMERICAN WELDING SOCIETY.

BOEDECKER APPOINTED MANAGER

W. S. Boedecker, member of the AMERICAN WELDING SOCIETY, has been appointed Manager of Production and Design of the K-G Welding and Cutting Co., Inc., which is now a subsidiary of Air Products, Inc. Until his appointment by K-G, Mr. Boedecker was for many years associated with The Bastian-Blessing Co. as engineer of welding and cutting equipment design.

J. A. MATHEWS

John A. Mathews was appointed on July 1, 1946, Chief Engineer of the Eagle Star Insurance Co. Ltd., 1, Threadneedle St., London, E.C.2. In addition to being a "Member" of the AMERICAN WELDING SOCIETY, Mr. Mathews is also connected with the following institutes: A. M. I. Mech. E., M. I. Mar. E., M. I. Inst. P., M. I. S. I., M. I. M., M. Inst. W.

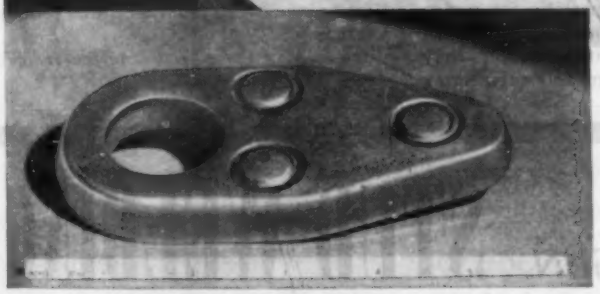
MURDOCH RETURNS TO SUPERIOR SLEEPRITE

Robert H. Murdoch who spent two years as factory manager at the Frank L. Wells Machinery Co., in Kenosha, Wis.,

Robert H. Murdoch

has returned to the Superior Sleeprite Corp. to be in charge of operations in their new plant in Los Angeles. Previously Mr. Murdoch spent about seven years with Superior Sleeprite as production head of their plants in Chicago. The new plant in Los Angeles is to be one of the largest installations in the West for production of steel furniture and bedding.

Need Help On Die Designs?



Give your problem to MALLORY Engineers . . .

In projection welding, a successful weld depends on good die design. Without such design, the parts to be welded may become scrap or may be improperly gaged for future assembly operations. That is why so many manufacturers turn to Mallory for expert assistance. *Mallory is headquarters for projection welding dies.*

The resistance welding die used to projection weld the steel stamping illustrated above is one in which Mallory design played an important part. An unusually large stamping for projection welding—5½" long, 2½" wide, ½" thick—it required a really top-notch die to be successfully welded. Mallory designed and built the needed die.

It's natural to bring problems like this to Mallory. No other company has greater experience in designing and building resistance welding dies . . . does more research . . . serves more industries . . . is more willing and able to be of help. Whenever you have a resistance welding design problem, save time and money—send it to Mallory.

In the United Kingdom, made and sold by MALLORY METALLURGICAL PRODUCTS LTD. (An Associate Company of Johnson, Matthey & Co. Limited) Hatton Garden, London, E.C.1.

The most comprehensive book ever published on resistance welding—complete with charts, diagrams, photographs. Free to those using resistance welding when requested on company letterhead.

P. R. MALLORY & CO. Inc.

MALLORY STANDARD RESISTANCE WELDING ELECTRODES

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

CONGRATULATIONS, MR. AND MRS. E. H. EWERTZ

We are pleased to learn from the Elizabeth *Daily Journal* of July 15th that Mr. and Mrs. E. H. Ewertz of 30 Farmington Ave., New London, Conn., celebrated their Golden Wedding Anniversary. This year also means a half century for Mr. Ewertz in submarine construction.

The former Elizabeth man is now consulting engineer for the Electric Boat Company, Groton, Conn. In 1896 he was a leader in the development of the submarine "Holland" first of the navy's underseas craft. The "Holland" was built at the Crescent Shipyard in Elizabeth and was delivered to the Navy in 1900. Mr. Ewertz was chief constructor at the yard.

Mr. and Mrs. Ewertz have four sons; Harold N. Ewertz, Philadelphia district manager for American Machine and Metals, Inc., of East Moline, Ill.; Roy W. Ewertz, a commission merchant in Mexico City; Clement O. Ewertz, a consulting engineer at Des Moines, Ia.; and Gordon E. Ewertz, a consulting engineer in New York. They also have six grandchildren.

Mr. Ewertz and the former Anna M. Nielsen were married in Brooklyn on July 15, 1896. Mr. Ewertz was born in Sweden on June 3, 1873, and came to America on Sept. 1, 1893. Throughout practically his entire business career, he has been active in ship construction of one form or another. Mr. Ewertz served as President of the AMERICAN WELDING SOCIETY from 1924 to 1925 and has been active in research and standardization work.

In 1941 Mr. Ewertz was the Electric Boat Co.'s representative at the Manitowoc Shipbuilding Co., Manitowoc, Wis., and Mr. and Mrs. Ewertz moved there. In 1943 they went to New London.

MANUAL OF ARC-WELDED DESIGN

Air Reduction has announced publication of "Manual of Design for Arc-Welded Steel Structures," a 300-page definitive work which is the first of its kind.

Compiled by LaMotte Grover, M. ASCE, who is widely recognized in the field of structural welding, this book offers a wealth of useful, up-to-date information covering fundamentals of design, materials, inspection, estimating and engineering control of welding and related operations.

Chapters are included to encompass electrode requirements, specifications for welded connections for all sizes of rolled beams, and a series of diagrams for the rapid design of welded connections.

Pointed, concise and complete, "Manual of Design for Arc Welded Steel Structures" is based largely upon standards of the AMERICAN WELDING SOCIETY, the American Institute of Steel Construction, and upon reports of the Welding Research Council of the Engineering Foundation.

Although the standardized beam connections and many of the details of design have been compiled especially for use in building construction, many of the design diagrams and fundamental principles may be applied to the design and engineering control of other types of welded steel construction.

Copies of this valuable, attractively bound manual are available for $2 from Air Reduction Sales Co., Dept. MD, 60 E. 42d St., New York 17. If, after a 10-day inspection period, a purchaser finds the book does not come up to expectations, he may return it to Airco and his money will be refunded.

WELDING PROCEDURE SHEETS

Two new arc welding procedure sheets have just been issued by Ampco Metal, Inc., Milwaukee 4, Wis., covering the use of Ampco bronze electrodes. These are entitled "Ampco Procedure for Welding Silicon Bronze" and "Ampco Welding Procedure for Beryllium Copper."

These welding procedures discuss the recommended electrode, polarity and current, preparation, preheat and detailed technical data on the welding of the base metal under consideration.

Information of this type is extremely helpful to welders interested in attaining quality welds with bronze electrodes.

The growing use of Ampco bronze electrodes throughout industry is the result of a better appreciation of the use of bronze in welding difficult applications. These electrodes are suitable for high strength joining of cast and malleable iron, steel and steel alloys to brass and bronze—in addition they are excellent for bronze overlays for wear and corrosion resistance.

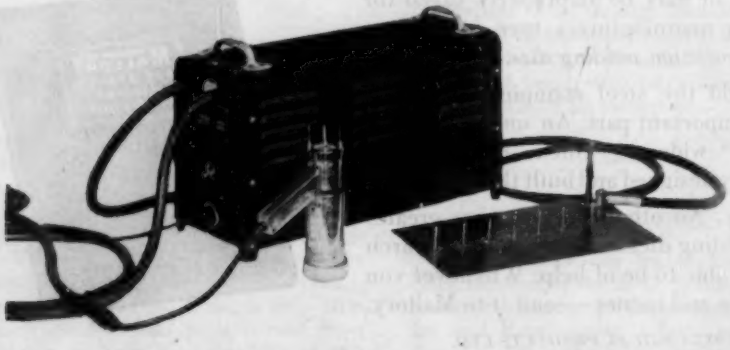
Copies of these procedure sheets will be sent on request.

ANNOUNCING

THE GRAHAM STUD WELDING GUN

ESPECIALLY DESIGNED FOR

STUD WELDING ALUMINUM



Mfd. by
BOSTON CUTTING DIE CO.
BOSTON, MASS.
Light Weight and Portable

FROM 1/16" TO 3/4" DIAMETER

Makes uniform welds simply and instantaneously without the use of timing devices or contactors.

Operation is economical and foolproof. The operator needs no skill or training.

Welds are clean, smooth and made without distortion or heating of metal. There are practically no craters or fillets and no flux is necessary.

NO GENERATOR IS REQUIRED

FOR FURTHER INFORMATION WRITE TO

C. H. STEVENS & COMPANY

15 ANN STREET · SOLE AGENTS · SOUTH NORWALK, CONN.

SAVED AGAIN! BY BRONZE WELDING

SEVEN YEARS AGO bronze welding saved the life of this 14-ton blank holder for a triple-action press. It stayed in service despite a few minor cracks and checks which later developed.

But recently, while forming turret tops for automobiles, a serious crack appeared and the valuable machine was down again. Once more it was Tobin* Bronze to the rescue: fractured on a Thursday, the holder was repaired and back in the plant the following Tuesday.

This was the score: 37 man-hours of chipping, 103 man-hours of welding, 600 lb. of Tobin Bronze.

This speedy rehabilitation job by the Super Arc Welding Co. of Detroit, is typical of the way low-temperature bronze welding saves valuable time and money in the reclaiming of worn, fractured or broken equipment. Applicable to cast iron, malleable iron, steel or copper alloys, bronze welding is also widely used in building up worn surfaces.

For detailed information on Anaconda Welding Rods, including Tobin Bronze and "997" (Low Fuming), write for Publication B-13. 46903

*Reg. U. S. Pat. Off.

ANACONDA

Anaconda

WELDING RODS

THE AMERICAN BRASS COMPANY

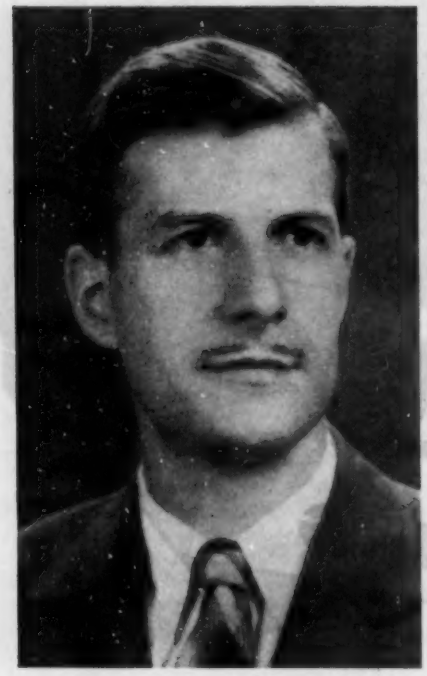
General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

MAAK OPENS OFFICE

Charles H. Maak has opened offices of the Pressure Weld Consulting Co. at 927 East Cypress Ave., Burbank, Calif., specializing in the field of oxyacetylene pressure welding. Research and development work in the welding of ferrous and nonferrous alloys, product design, design of welding equipment, and process installation are among the services offered. Maak recently left the Menasco Manufacturing Co., of Burbank, where he was responsible for much of the development work which made possible the employment of pressure welding in the fabrication of aircraft landing gear. He is a 1938 engineering graduate of the Massachusetts Institute of Technology and is a member of the AMERICAN WELDING SOCIETY.



Charles H. Maak

FRUEHAUF ISSUES STAINLESS STEEL TRAILER CATALOG

A 16-page illustrated catalog covering the new line of Fruehauf Welded Stainless Steel Trailers has just been released, according to W. D. Wise, Fruehauf Director of Advertising.

The book states that 98 out of 100 stainless steel trailers produced by the company prior to the war are still on the road. Brief excerpts of reports from operators are included.

Sweeping improvements in body construction and mechanical features are described in detail, and the company's new and modern production facilities are pictured.

Fruehauf has also issued a maintenance manual and parts catalog covering Model GT-55, which describes the new Gravity Suspension Tandem under construction. Copies of the booklets are available through Furehauf factory branches.

WHY SCRAP SUPPLY IS SHORT AND OTHER BACKGROUND INFORMATION

During the coal strike a larger percentage of scrap than normal was used in furnace charges because there was no coal to make pig iron. Consequently, already low supplies of scrap were brought to rock bottom.

Strikes in consuming and fabricating industries, from which a large part of the scrap normally comes, have cut that supply drastically.

Battlefield scrap has not been returned in expected quantities due to chaotic conditions in the countries abroad.

Uncertain price situation has hampered flow of scrap. (However, reinstatement of OPA has resulted in reinstatement and conformation of former scrap price ceilings.)

Unable to get new equipment, potential buyers have been forced to hold onto their old. . .railroads, for instance, cannot tear up old track or scrap locomotives until replacements are available. Farmers cannot scrap old equipment until they get new equipment.

Auto "graveyard" scrap is low because they are a source of valuable parts and this scrap will not move as scrap until the automobile demand is saturated.

Labor shortage in scrap yards.

Scrap normally makes up 50% of the charge in an open-hearth furnace from which by far the greatest proportion of all the steel comes.

For Low Cost Acetylene
...give me a Sight Feed
● Sight Feed Acetylene Generators make you independent of an outside source of supply for acetylene—generates the acetylene you need, as you use it, in your shop or factory.
● Sight Feed Acetylene Generators keep you from running out of acetylene and losing heat on the middle of a job—you see the carbide charge in the hopper and you know you have enough before you start.
● Sight Feed Acetylene Generators soon pay for themselves—and pay you extra profits for years—as you save from 50% to 75% over the cost of "bottled" acetylene.
● Stop at your jobber's store and get the facts or write for catalog 44-G.
ACETYLENE GENERATORS • FLOODLIGHTS • FLARELIGHTS
ACETYLENE Sight Feed GENERATORS
THE SIGHT FEED GENERATOR COMPANY
RICHMOND, INDIANA

THE NAME SYNONYMOUS WITH WELDING CABLE

*SUPER-FLEXIBLE RUBBER COVERED Welding Cable

The Arc Welding Industry voted "MAJOR" Welding Cable their first choice of brand names. The shipyards, ordnance plants and independent arc welding engineers backed their judgment with purchases of hundreds of thousands of feet of "MAJOR" Cable. "MAJOR" is STANDARD—Super Flexible, having a paper separator for quick stripping and attaching to lugs and holder. Spiral winding of fine copper strands in the conductor increases flexibility and insures maximum power transmission. Extruded type rubber covering is maximum oil and abrasion resistance. "MAJOR" is good welding cable.

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The fastest selling cable on the market today. Nothing can surpass it!

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• FULLY INSULATED •
ELECTRODE HOLDER
All objections to other holders have been eliminated. "Continental" is a perfect holder.

3
"CONTINENTAL"
• FULLY INSULATED •
CABLE CONNECTOR
In the same superior class as the "Continental" electrode holder.

4
"LIBERTY"
WELDING HELMETS
Are made of lightweight fibre with adjustable headgear.

5
"MONARCH" LENS
High Quality protection plate in #10 and #12 shades, size 2 x 4⅛".

WECo

The biggest producers of scrap are generally the railroads, automotive industry, farms, factories.

The steel industry was able to increase its operating rate in July by using more pig iron, in place of scrap. However, the limit has just about been reached in this respect.

Twenty-five to 30 open-hearth furnaces were idle August 1st for lack of scrap, against 12 idle for same reason July 1st. Meanwhile, during July receipts of scrap by steel mills fell from an average of 60% of requirements to approximately 40% of requirements. If the flow of scrap remains at its present poor rate, mill inventories of scrap will vanish in four to six weeks.

"Everyone who is waiting for steel can help the steel industry by assisting the movement of scrap."

HYDROGEN SUPPLY

The 1946 edition of "Ammonia in Metal Treating," a 40-page illustrated booklet, has been published by the Mathieson Alkali Works and is now available on request from the company at 60 E. 42nd St., New York 17, N. Y.

The booklet explains in detail the use of ammonia, either as a furnace atmosphere or as a source of pure hydrogen, in nitriding, dry cyaniding, bright annealing, copper brazing, powder metallurgy, atomic hydrogen arc welding and oxyhydrogen arc welding. Installations of these processes in metal working plants are described and illustrated.

The chemical and physical properties of ammonia and the general precautions to be observed in its safe handling and application are fully discussed.

DIEBOLD JOINS WURLITZER

John M. Diebold, who was associated for the past several years with the GMC Truck and Coach Division of General Motors as welding engineer, has recently assumed the duties of Production Engineer with the Rudolph Wurlitzer Co., North Tonawanda, N. Y.

John M. Diebold

While at GMC Truck and Coach, Mr. Diebold was active in the AMERICAN WELDING SOCIETY'S technical activities, having served as first chairman of the A.W.S. Automotive Welding Committee, and as a member of the A.W.S. Army Ordnance Advisory Committee. He continues to serve as a member of the A.W.S. Resistance Welding Committee.

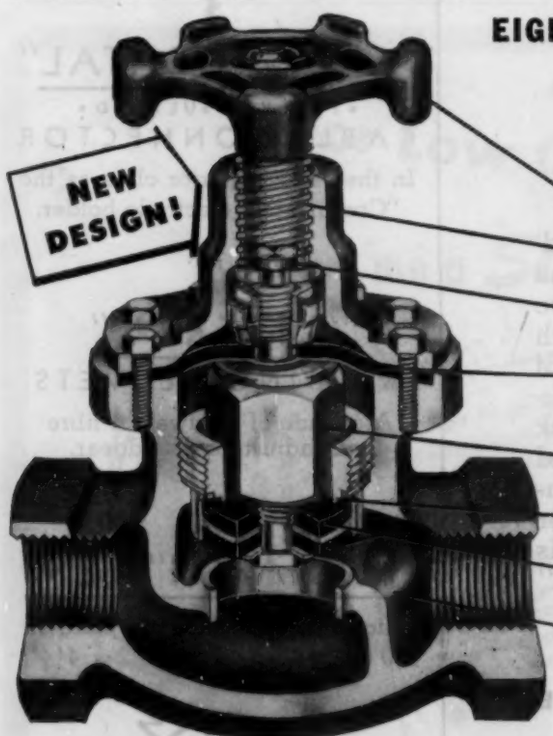
While in Detroit, Mr. Diebold was active in Local Section affairs, and served for several years as a member of the Executive Committee of the Detroit Section of A.W.S.

Before coming to GMC Truck and Coach in 1940, Mr. Diebold was associated for about eight years with the Engineering Division of Chrysler Corp. Mr. Diebold received his education in mechanical engineering at the University of Colorado in his native state. In his new position with Wurlitzer he will continue his interest and activities in welding engineering, but will also encompass other production processes as well.

HOLLUP CATALOG

A new and complete 64-page catalog of all Hollup electrodes and National oxyacetylene gas welding rods has just been published by the Hollup Corp., a division of National Cylinder Gas Co., Chicago.

Included are complete descriptions, color identifications, specifications con-



RegO Globe and Angle Valves are available in the following sizes: ¾", 1", 1¼", 1½" and 2"

EIGHT REASONS *why* YOU SHOULD SPECIFY...

REGO GLOBE *and* ANGLE VALVES

to eliminate hazardous and costly leaks!

1. **HANDWHEEL** . . . improved hand grip for easier operation.
2. **ACME THREADS** . . . quick acting, heavy-duty performance, longer engagement in bonnet.
3. **SWIVEL STEM** . . . gives vertical movement to seat disc, eliminates chances of seat scoring.
4. **DIAPHRAGM** . . . provides positive seal of valve stem, eliminating need of taking-up wear or repacking required with ordinary packed-type valve.
5. **SEAT DISC ALIGNMENT** . . . positive seating of disc assembly due to hexagonal guide.
6. **BACK SEATING** . . . permits replacement of diaphragm without shutting down line.
7. **SEAT DISC** . . . special long-life composition, positioned mechanically as there is no dependency upon springs.
8. **LARGE CHANNELS** . . . flow through valve is accomplished with minimum friction loss.

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Pioneer and Leader In The Design and Manufacture of Precision Equipment for Using and Controlling High Pressure Gases.

HOW MUCH WELDING RESEARCH IN A BAG?...A TON?...A CARLOAD?

There was a time, we're told, when electrodes were the product of a "back yard clay pile and a few lengths of iron wire." This day of simplicity has gone.

From our corner of the welding business, for example, we supply alloying and slag forming materials, arc stabilizers, binders, fluxes, organics, scavengers, and slipping agents . . . and from one to two dozen products in each classification. We're mighty fussy about quality. Our laboratories hum with control analyses of all shipments.

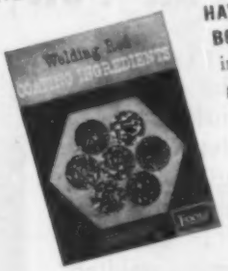
Extruding experimental rods in Foote Welding Laboratory

In our lab, we have heavy duty extrusion and slugging presses and mixers, drying ovens, strength and hardness testers, welders . . . and men who know how to use them.

Whether you buy a bag, a ton, or a carload of Foote welding rod coating materials, you get a full measure of technical advancement.

Welding with experimental rods in Foote Laboratory

Equally important to you . . . our researchers are continually "scouting" for new material resources, developing new products and processes, improving old ones.



HAVE YOU THIS NEW BOOKLET? — "Welding Rod Coating Ingredients" describes materials, services, and publications available from us. Send request on your letterhead.

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A Step Ahead in Industrial Ores and Chemicals

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Home Office: 511 GERMANTOWN TRUST COMPANY BLDG., PHILA. 44, PA.
West Coast Representative: Griffin Chemical Co., San Francisco, Cal.

formed to, physical properties, welding procedures, recommended ranges and sizes available in the whole line of Hollup electrodes—mild steel, alloy steel, stainless, hard facing, cast iron, etc.

There are tables on the weldability of metals, appearance inspection of welds, electrode consumption estimating chart and definitions of welding terms.

A copy may be procured by addressing Hollup Corp., 4700 W. 19th St., Chicago 50 Ill.

RESIDUAL STRESSES IN WELDED STRUCTURES

How seriously the combination of low ductility and high residual stress affects the load-carrying capacity of welded joints connecting steel plates, is the problem considered in detail in Bulletin No. 361, "Residual Stresses in Welded Structures," by Wilbur M. Wilson and Chao-Chien Hao, recently published by the Engineering Experiment Station of the University of Illinois.

The new publication includes an analysis of various theories of residual stress, and complete reports on tests to determine the behavior of welded seams under loads, tests to determine the behavior under static loads of plates with circular welded seams, and fatigue tests of plates with longitudinal butt welds.

For the present, copies of Bulletin No. 361 will be mailed free on request from the Engineering Experiment Station, University of Illinois, Urbana, Ill.

FOUNDRYMEN'S ASSOCIATION ACTIVITIES

R. J. Allen, metallurgical engineer, Worthington Pump & Machinery Corp., Harrison, N. J., heads the 1946–47 program and papers committee of the gray iron division of the American Foundrymen's Association, T. E. Eagan, Cooper-Bessemer Corp., Grove City, Pa., division chairman, has announced.

R. G. McElwee, manager, foundry alloy division, Vanadium Corp. of America, Detroit, is vice-chairman and T. D. Parker, metallurgical engineer, Climax Molybdenum Co., New York City, will serve as secretary.

Other members of the new committee are W. W. Levi, metallurgist, Lynchburg Foundry Co., Radford, Va.; K. H. Priestley, Vassar Electroloy Products, Inc., Vassar, Mich.; A. E. Schuh, director of research, U. S. Pipe & Foundry Co., Burlington, N. J., and J. S. Vanick, International Nickel Co., Inc. New York City.

The division's steering committee, at a recent meeting, tentatively decided to schedule four gray iron sessions of three papers each for the association's 1947 convention. One session would be a symposium on heat treatment and another, a welding practice symposium.

PROGRESSIVE REPRESENTATIVES

Appointment of K. P. Swanson, 204 Chapel St., Abington, Mass., to represent Progressive Welder Co. in Eastern Connecticut, Eastern Massachusetts, Rhode Island, Maine, Vermont and New Hampshire has been announced by L. M. Benkert, Sales Manager of Progressive Welder.

Mr. Swanson joins V. A. Chern who maintains offices at 15 Gramercy Park, New York 3, in covering the New England area on the company's line of resistance welding equipment. Mr. Chern is covering the New York Metropolitan District as well as Western Connecticut and Western Massachusetts. H. B. Axtell, with address at 171 Forest Ave., Verona, N. J., covers Eastern New York and Northern New Jersey. All of these representatives are members of the AMERICAN WELDING SOCIETY.

THE 1946 ADDENDA TO THE BOILER CONSTRUCTION CODE

Rules in the Power Boiler Code affected by the 1946 changes and revisions are those covering piping, welding of Ogee ring, welding of door rings, doubling plates or riveted washers, welding operators when welding on boilers, the tables of allowable working stresses, etc.

The Addenda to the Unfired Pressure Vessel Code include further revisions of the requirements for rupture disks, rules for computing conical heads under internal pressure, and changes in ductility requirements for various steels.

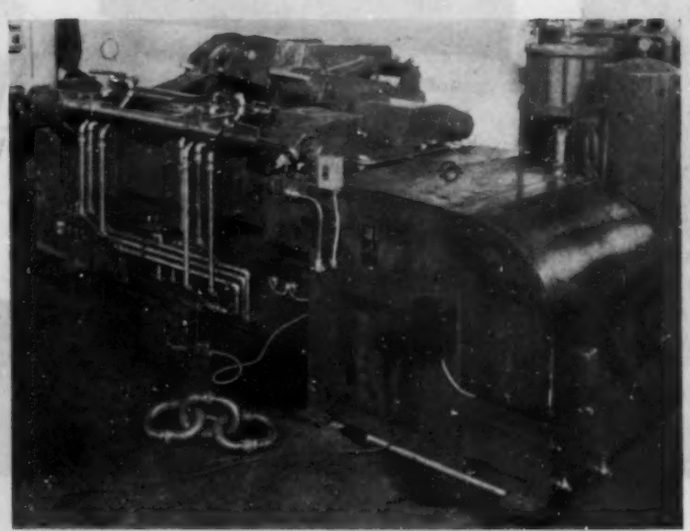
There are provisions for the sue of unflanged heads in vertical miniature boilers; for the use of staybolted syphons in locomotive fireboxes and combustion chambers, and for staying of unflanged heads in welded heating boilers.

New Material Specifications have been added; while a number of the existing specifications have been revised.

WE OFFER FOR IMMEDIATE DELIVERY

Extra-heavy National Mill Type Flash Butt Welder, powered by 900 KVA water-cooled welding transformer, 440 volt, 60 cycle. Movable platen actuated by two hydraulic cylinders of 12″ diameter, with feed controlled by cam-operated hydraulic unit. In excellent condition, and capable of easily welding 14 square inches in alloy steel. Complete with special welding contactor of 1800 ampere nominal rating, fully enclosed, and with low-voltage operating control.

Double-acting Hydraulic Flash-shear of sturdy design, 12″ piston diameter, with 20″ stroke.



Location: Linden, N. J. May be seen by appointment.

THE MATHER SPRING COMPANY

TOLEDO, OHIO

Here's one place radiography more than pays its way . . .

IN ESTABLISHING THE SOUNDNESS OF WELDS:

it's no longer necessary to destroy the weldment. Radiography provides visual evidence of the internal condition of the weld . . . makes it possible to determine more positively whether the weld is sound . . . often saves enough thereby to pay for the radiographs many times over.

Here's another . . .

IN IMPROVING THE TECHNIC OF WELDING:

radiography is virtually a must. Using x-rays at regular intervals, you can show each welder the quality of his work and keep complete track of his progress . . . thus know that his work is thorough and efficient on the job at hand. Think of it!

And another . . .

IN CREATING ACCEPTANCE FOR WELDING:

put yourself in the buyer's chair. You'd buy more welded parts, wouldn't you, if you could see *proof* of their soundness? That is precisely why radiography can help you increase the use of welding so much you'll be happy to pay the cost of the x-rays.

For more information about radiography to fit your particular needs, call in your local x-ray dealer or write . . .

EASTMAN KODAK COMPANY · X-ray Division · ROCHESTER 4, N. Y.

Radiography . . . another important function of photography

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AIRCO PUBLISHES NEW ELECTRODE SELECTION CHART

A graphic, four-color, 25-x 40-in. electrode selection chart has been published by Air Reduction to assist operators in the choice of the correct electrode for a particular job.

The chart specifies which electrodes to use, shows currents, gives mechanical properties and also includes an electrode color guide which shows the electrodes in their actual colors.

Included are electrodes for mild, alloy, and stainless steels, as well as for nonferrous, cast-iron and hard-facing rods. A separate section at the bottom of the chart is devoted to special purpose electrodes.

A copy of this extremely helpful shop aid may be obtained from Air Reduction Sales Co., 60 E. 42nd St., New York City.

NEW NICKEL ALLOY CATALOG D-2 OF WIRE, ROD AND STRIP

Choosing wire, strip or rod of uniform dimensions for difficult high temperature or corrosive applications is made easier by reference to the engineering data and illustrations in a new catalog offered by Alloy Metal Wire Co., Inc., Prospect Park, Pa.

Alloy Metal's catalog sections include engineering information on strength, electrical resistivity, modulus of elasticity, heat treatment, temperature limits and magnetic properties. The metals covered are the high-nickel content alloys, Monel, Nickel, "Z" Nickel, "L" Nickel, Inconel and specialized Monels ("K," "R" and "KR") for machining and heat-treating properties.

The new catalog, which is being sent in response to all requests made on business letterhead, contains sizes, weights, tolerances and other information helpful in writing specifications and ordering. It also includes many illustrations of wire, rod and strip used in springs, wire cloth fastenings, paper mills, jewelry, mechanical and electrical applications.

WELDING MANUAL ON ALUMINUM

Gas welding, arc welding, resistance welding, brazing and soldering are the principal headings in *Reynolds Metals*, new 88-page book devoted to bringing to users of aluminum a comprehensive résumé of the latest practices and recommendations for joining aluminum by these processes.

After a brief discussion of the more widely used aluminum alloys from the standpoint of factors affecting their weldability, the book analyzes recommended gas-welding practice with sections covering such topics as edge preparation; cleaning and preheating; the welding flame; welding rods, fluxes and technique.

The arc-welding material includes chapters on the metal-arc, carbon-arc, atomic-hydrogen and inert-gas-shielded processes. Resistance welding is broken down into sections on spot welding by four different methods; seam and flash welding, with information on preweld cleaning, recommended machine settings, tip pick-up, and where to look to correct trouble. Subsequent chapters discuss furnace and torch brazing, soldering, inspection of welds, metallurgy of welds, and the like.

The book is available from Reynolds Metals Co., Dept. 47, 2500 S. Third Street, Louisville 1, Ky. Price $1.00 each.

HANDY SELECTOR FOR ALUMINUM ALLOYS

A mass of technical information concerning 18 of the most widely used aluminum alloys is presented in easy-to-use form in Reynolds Aluminum Alloy Selector—a slide-rule type of chart in standard $8\frac{1}{2}$ x 11-in. size.

The main horizontal slide is pulled to line up with the aluminum alloy under consideration. Then the chart reads directly the chemical composition in per cent for twelve elements and shows physical constants including specific gravity, density, modulus of elasticity in tension and torsion, coefficient of thermal expansion, thermal and electrical conductivity, spe-

SURPLUS

SCIAKY ALUMINUM SPOT WELDERS

They are thoroughly factory-reconditioned, installed, serviced and "new-machine" guaranteed by the original maker.

They are offered at a savings of nearly one half. Welders formerly $9,100 to $10,160 are priced at $5,500 to $6,500, complete with rectifier . . . some with built-in rectifiers.

The machines are rated 50 KW and operate on the exclusive Sciaky Electromagnetic "Stored Energy" principle with patented "Variable Pressure Cycle." Capacity on aluminum and other light alloys: .016" plus .016" up to and including .080" plus .080". Speed on two thicknesses of .040" is 80 spots per minute. Throat depth is 36".

The quantity is limited. You are urged to act at once. Write, phone or wire for details.

SCIAKY BROS. Inc.
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Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them *Unequalled for Quality*

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4 for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY

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TIP CLEANING **DRILLS**
Mounted in Knurled
BRASS *Handled*

LARGE STOCK
PROMPT DELIVERY
NO RATING REQUIRED

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Time Counts—
Gas cut and Weld with

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Join The American Welding Society

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CESCO FOR STYLE

• Workers—both men and women—prefer to wear *good looking* safety equipment. They choose CESCO because CESCO goggles and shields are designed to *look attractive* as well as to protect wearers from injury. Styling goes into *all* CESCO equipment, not only for good looks, but also for serviceability and comfort.

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• CESCO safety equipment includes every comfort feature—minimum weight, easy-resting contact points, good ventilation where ventilation is needed. All equipment is scientifically formed and adjustable to fit varying head and facial contours.

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• CESCO Safety Equipment saves two important ways—the emphasis on quality makes CESCO products long-lasting and economical. Above all, CESCO equipment protects workers from head and body injury, saves life and precious eyesight.

CESCO FOR SERVICE

• When you use CESCO safety products you get *serviceable* equipment plus the *service* of men well qualified to advise you on your safety needs. When you add them all up—style, comfort, savings and service—your logical choice is CESCO Safety Equipment.

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CESCO FOR SAFETY

cific heat. Data are also given on maximum forging temperature, recommended cycles for solution heat treatment as well as precipitation heat treatment and annealing.

Then by moving a second slide vertically to line up with one of seven different product forms (sheet, plate, wire, rod-bar, shapes, tubing-pipe, forging), the chart shows tempers available in that product form; ranges of tensile strength, yield strength, hardness and elongation; comparable A.M.S., A.S.T.M., Federal and Navy specifications.

Aluminum alloys covered include 2S, 3S, 14S, 17S, 18S, 24S, Pureclad 24S, 25S, 32S, A51S, 52S, R353, 56S, R361, R301, R303, Clad R303, R317. Thus by setting one slide for the alloy and the other slide for the product, the user has available in handy form data on mechanical properties, chemical composition, physical constants, thermal treatments and specifications. This greatly simplifies selection of the desired alloy and temper for a particular application.

In addition, the chart includes an explanation of alloy and temper designations as well as a brief description of outstanding properties of each of the 18 different alloys.

Charts are available from Reynolds Metals Co., Dept. 47, 2500 S. Third St., Louisville 1, Ky. Price $1.00 each.

TWIN-UNIT OUTDOOR A.-C. ARC WELDER BY GENERAL ELECTRIC

A new twin-unit, outdoor a.-c. arc welder in a single enclosure has been announced by the Electric Welding Div. of the General Electric Co. Each of the two circuits in the welder can be used simultaneously and independently with electrodes up to $^{5}/_{16}$ in. in diameter, or com-

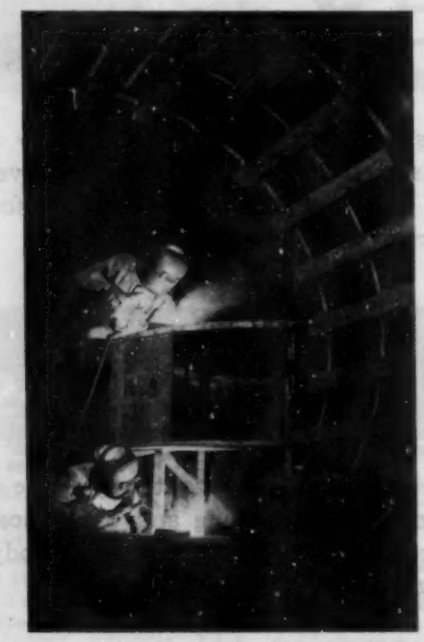
bined into one circuit for heavy welding with $^{3}/_{4}$-in. electrodes. The units have a current range of from 90 to 270 amp., when used singly and from 180 to 540 amp. when operated in parallel.

Both welders are equipped with control which reduces the open-circuit voltage to approximately 30 v. when the machine is not welding, but which makes full power available the instant the arc is struck. Both halves are supplied through a single set of primary terminals, so that only one power-line circuit to the unit is required.

Protection against rain, snow and sleet is provided by dripproof construction of all openings in the top of the enclosure and by a sealed window over the current indicators. Ventilating openings at top and bottom are of such proportions that they shed water and keep the ventilating air velocity low.

WELDED TURBOGENERATOR

A team of welders seals the joints of a frame for a turbogenerator at the East Pittsburgh Works of the Westinghouse Electric Corp. When completed, this



frame will be a part of the generating equipment to turn out electric power for busy industrial plants. The big circular "ladder" in the foreground is a frame for a 4500-hp. electric motor.

USE OF 27% CHROMIUM-IRON EQUIPMENT

Recommendations for more effective use of 27% chromium-iron equipment employed in making butadiene from petroleum were outlined by H. D. Newell, Chief Metallurgist of The Babcock & Wilcox Tube Co., Beaver Falls, Pa. These recommendations are based on studies originally made for the Rubber Reserve Co., now the Reconstruction Finance Corp., Office of Rubber Reserve, and which were intended primarily for manufacturers of raw materials for synthetic rubber.

Embrittlement Limits Life of Alloy

Mr. Newell stated that, in general, embrittlement, due to sigma phase precipitation or "885° F. embrittlement" (or both), would appear to be the one most deleterious factor curtailing the useful life of this alloy in dehydrogenation plants. Sigma phase is a brittle intermetallic iron-chromium compound which forms in alloys containing more than about 25% chromium on long heating in the range from about 950 to 1250° F. Its preciptitation causes increased hardness and drastic loss of ductile properties.

"An understanding of the characteristics of this alloy, especially its grain growth in welding, lack of transformations during heat treatment, its extreme notch sensitivity, and its tendency to become embrittled within the range of temperatures encounted in the dehydrogenation process, warrant several suggestions in the interest of securing satisfactory service and of minimizing maintenance and breakage," Mr. Newell continued.

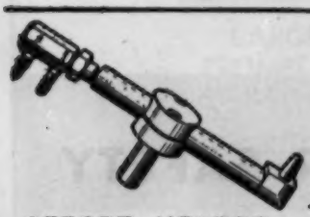
The recommendations he gave concerned subjects such as welding repairs, avoidance of notches, elimination of shock stresses, elimination of 885° F. embrittlement and heat treatment to remove sigma phase.

For welding, he suggested use of a nickel-bearing austenitic or partially austenitic welding electrode, preheating before welding, stress relieving at 1300° F. minimum immediately afterward, followed by rapid cooling.

"Sharp notches and re-entrant angles in design or repair should be avoided, as well as folds, nicks, scratches or stamping of numbers," Mr. Newell said. "Shock stresses ought to be avoided, but if required, should be performed when the metal is at 550° F. or higher. The use of copper gaskets on certain types of flanges and hand hole fitting seats has helped maintain tight, leakproof joints. Graphite, applied to threads and contact areas of bolted fittings, will reduce galling and sticking.

How to Avoid Embrittlement

"In order to avoid 885° F. embrittlement, cooling after service through the 1100 to 700° F. range should be relatively rapid. Below 700° F., the cooling should be more moderate. Sigma phase may be removed by heating for not less than 1 hr.



Welding cast iron?

Here's a way... to get good welds on the toughest jobs

SEEMS as though there's no end to the fine reports we get on Ni-Rod.

Welding shops are using Ni-Rod for jobs they'd never tackle before. *Foundries* are using Ni-Rod to repair defective castings quickly and easily. *Maintenance men* are using Ni-Rod for time- and money-saving repairs of broken and worn castings.

Ni-Rod is even being used on production lines.

Why does one electrode find such broad use?

Because Ni-Rod welds are strong welds... sound welds ...machinable welds.

And... because Ni-Rod is the easiest-handling electrode ever developed for welding cast iron.

If you haven't tried Ni-Rod, order a package today... sizes are 1/8", 5/32" and 3/16". You'll find plenty of jobs for this electrode. Ni-Rod gives you a stable arc in all positions on either a.c. or d.c. Deposits are smooth, close to the color of cast iron and free from cracks and porosity.

Welders who use it, say, "*Ni-Rod is the easiest way to get the best welds in cast iron.*"

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

Send for Ni-Rod Instruction Booklet

NON-POROSITY was a "must" for this Ni-Rod repair job!

COMPANY
B. F. Goodrich Company, Akron, Ohio.

CASTING
One half of a steam-jacketed tire mold.

DEFECT
A thin section just above the steam and condensate ports.

PREPARATION OF THE WELD
The thin section was cut away until sound metal of at least ¼" wall thickness was found at all boundaries of the cut.

A steel patch plate was then fitted into the opening. Edges of both plate and the surrounding cast iron were beveled to a vee of 75-90 degrees.

The entire half of the mold was preheated to 300° F.

WELDING
Using Ni-Rod, the inner and middle seams were welded and allowed to cool somewhat. Then, the outer seam was welded and lightly peened to counteract contraction stresses. Mold was allowed to cool slowly to room temperature.

TESTED
At 200 psi. water pressure.
At 100 psi. steam pressure.

COMMENTS
Several molds with similar casting defects have been repaired in this manner. No porosity has been detected. The welding has caused no appreciable distortion.

INCO NI-ROD

NI-ROD IS DISTRIBUTED BY:

WHITEHEAD METAL PRODUCTS COMPANY, INC.—Baltimore, Boston, Buffalo, Newark, New York, Philadelphia, Syracuse

WILLIAMS and COMPANY, INC.—Cincinnati, Cleveland, Columbus, Pittsburgh

STEEL SALES CORPORATION—Chicago, Detroit, Indianapolis, Milwaukee, Minneapolis, St. Louis

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METAL GOODS CORPORATION—Dallas, Houston, New Orleans, Tulsa

EAGLE METALS COMPANY—Portland, Seattle

HENDRIE & BOLTHOFF MFG. & SUPPLY CO.—Denver

ROBERT W. BARTRAM—Montreal

ALLOY METAL SALES, LTD.—Toronto

WILKINSON COMPANY, LTD.—Vancouver

at a minimum temperature of 1500° F., and quickly cooled through the range 1100 to 700° F. so as to avoid the 885° F. embrittlement.

"Regeneration procedures must be controlled at all times to prevent overheating. An excessive temperature would be one that is high enough for carburization of the metal, which probably means temperatures in excess of about 1700° F. Ordinarily, the maximum temperature reached during normal operations of dehydrogenation should not exceed about 1350° F. except during heat treatment for sigma phase removal."

DRYDOCK LAUNCHING

While thousands of Pittsburghers looked on Saturday, Aug. 10th, the largest vessel ever to be built on the inland rivers of America was launched into the Ohio River. The vessel is the ARD-33, a floating drydock designed by the Bureau of Yards & Docks, Navy Dept., for the use of the Bureau of Ships. It was built under the supervision of Bureau of Yards & Docks by Dravo Corp. at its Neville Island Yards at Pittsburgh, Pa., for the U. S. Navy. This shiplifting giant is 448 ft. long by 97 ft. wide and 45 ft. high. When it is completely outfitted it will leave the Dravo yards under special tow and be taken 2000 miles by water through the locks of the Ohio River and down the Mississippi. Defined by the Navy as an auxiliary repair dock, ARD-33 will have a lifting capacity of 6000 tons. It is particularly designed to serve auxiliary or tender type ships as well as Liberty Ships. These vessels in many cases were formerly commercial type ships built for or put to Navy use during World War II.

Fig. 1

Because of its size and shape, ARD-33 could not be launched in the conventional manner. To avoid undue stresses in launching, it was built on a declivity—its flat bottom parallel to the sloping ways. The declivity was 1 1/2 in. in 12 in. A full revolving traveling crane, weighing 135 tons, was placed aboard as soon as the well deck was completed, to facilitate erection of sidewalls and handle heavy lifts.

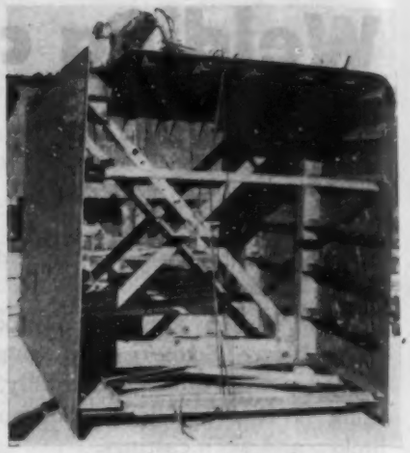

Fig. 2—Box Section Being Readied for Movement to the Building Ways

Sections were shop fabricated, moved to a construction area as needed, then positioned and welded to the main structure. This method of preassembling sections was used successfully by Dravo when the plant was engaged in producing LST's for the Navy during World War II.

After the launching of ARD-33, the hull was towed to an outfitting dock where work of completing the vessel is now under way. The structure is butt welded and contains more than 73 miles of welding.

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with G.E.'s *Current Regulator*

● The operator of this traveling resistance-welder at the Pullman Standard Car Manufacturing Co., gets consistent welds automatically

Equipped with a G-E electronic current regulator and synchronous control, this resistance welding machine travels the length of the Pullman car producing uniform welds automatically. Each of these welds is of equal strength because the current regulator *automatically compensates for varying line voltage and secondary circuit impedance.*

In welding these cars, two spot welds are made at a time, the spacing between the two varying in accordance with the dimensions of the parts and the strength specifications. As the spacing varies, the length of the secondary circuit changes, and in turn the current is changed.

Where formerly this shift meant frequent readjustments by the operator, guided by an extensive table of machine settings, now just one of two settings is needed, depending on whether the machine is welding Cor-Ten or stainless steel; the current regulator does the rest.

This regulator holds current within plus or minus 2 per-cent of normal, whereas, the unregulated current might vary as much as plus or minus 20 per-cent.

Even when space is uniform, current is affected by varying amount of magnetic material in current loop.

IMPROVES QUALITY

In this, and other applications such as welding propeller blades, metal barrels, etc., this regulator provides uniform quality welds when more or less metal is introduced in the welder throat.

FLEXIBLE OPERATION

The same settings can be used when operating a press-type spot welder, a gun welder connected to the same transformer, or when welding magnetic materials with a press-or gun-type welder.

—The current regulator is specially designed for use with G-E electronic resistance welding controls which include heat control by the phase-shift method.

For additional information ask our nearest local office for Bulletin GEA-4220. *Apparatus Department, General Electric Company, Schenectady 5, N.Y.*

GENERAL ELECTRIC

Fig 3

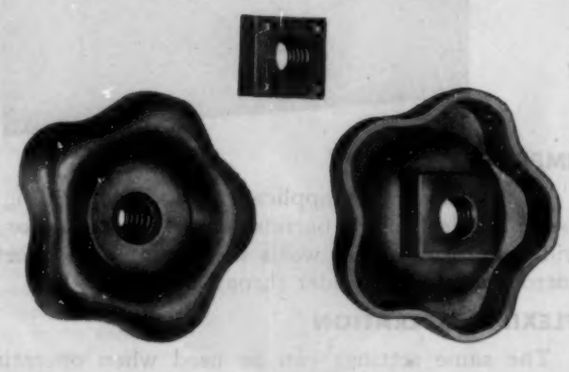
Over 73 miles of welding was done on ARD-33—the largest butt-welded structure ever built by Dravo Corp. Automatic Welding was used to a great extent. Scaffolding was welded to wingwalls, another Dravo-developed construction aid.

It is nonself-propelled, since drydocks of this class are moved infrequently. The vessel is designed to accommodate a crew of 130 men and 7 officers.

To mechanically test the operation of drydock before it is sent to sea, dredging has been done in the Ohio River near Rochester, Pa., to provide a depth sufficient to enable submergence tests to be made. While these river tests will accurately determine the time required to submerge and emerge, it is believed that the dock can be lowered to receive a vessel in less than 30 min. and subsequently emerge by pumping out its tanks in about 2 hr.

The drydock is a self-contained unit. It has its own water distillation plant, sanitary disposal facilities, diesel electric generator sets for light and power, and the crew quarters are such that the men will be comfortable in any climate. Machinery spaces, workshops and crew quarters are contained in the 12-ft. wide sidewalls. Crew quarters are modern, and recreational facilities include a soda fountain and moving picture projector. The tremendous storage capacity available for food, repair parts and material means the vessel could operate many months at remote locations with limited tender or supply service. A watertight longitudinal bulkhead runs the entire length of the hull. Eight watertight tanks on each side provide the means for submerging and raising the dock. Each of the 16 tanks is served by a pump and flooding valve and all tanks can be filled or pumped out simultaneously, if

Ohio Weld Products
for projection welding



This large adjusting nut made by welding an Ohio Square Weld Nut to a stamping, illustrates one of the many applications where Ohio Weld Products help increase production and reduce cost. The welding is done on Standard Press Welders.

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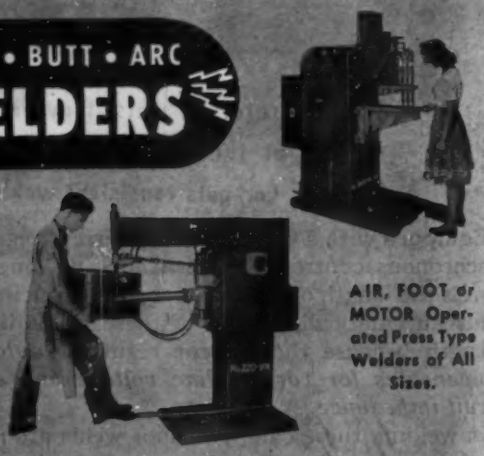

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Transformers of all types.

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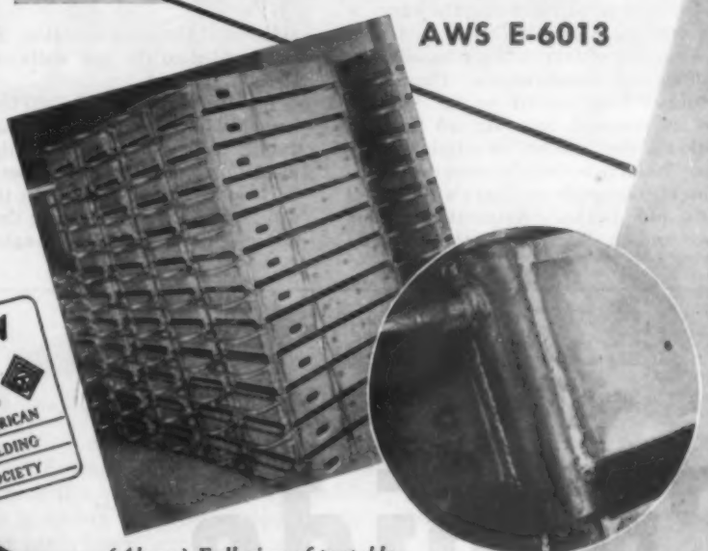
AWS E-6013

EXCELLENTLY adapted to thin gauge metal, ***GRAYDAC*** Electrode provides just sufficient penetration to make a good bond which allows for grinding flush without weakening the weld. On vertical down the bead is flat and exceptionally smooth. Spatter is held to a minimum and slag easy to remove.

Competitive tests showed ***GRAYDAC*** superior in bead appearance, penetration, ease of starting, vertical performance and all 'round handling. ***GRAYDAC*** is especially recommended for use with the low input type of Transformer Welding Machine.



(Above) Full view of portable machine bases and close up view of corner weld made with ***CHAMPION GRAYDAC*** *Electrodes.*

(Above) Full view of bases for meat cutting machines and close up of corner weld made with ***CHAMPION GRAYDAC*** *Electrodes.*

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APPLICATIONS

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Farm Equipment	Air Conditioning Equipment
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CLEVELAND, OHIO — EAST CHICAGO, IND.

need be, as control is maintained from a central station. An indicating system is provided that shows the dockmaster the depth of water in all compartments at all times.

Two full-revolving, rail-mounted gantry cranes will operate from either side of the wing wall deck. They are of 20 ton capacity. Rail joints are welded and rail clips and plates are welded to the deck itself. Scuppers are formed from extra strong steel pipe, with bells of welded steel plate

All doors and windows are provided with spring bronze weather stripping. Chain pipes are of fabricated steel and concrete keel blocks are provided for the docking chamber, because of the scarcity of suitable grades of lumber.

Since docking and undocking a vessel is a highly complicated technical operation, because of the great weights and forces involved, crewmen assigned to the vessel will have had either previous drydock experience, or training at the Navy's Floating Drydock School. The ARD-33 is 120 ft. longer than the LST's of which Dravo constructed 150 during the war.

In erecting ARD-33, Dravo used their usual method of fabricating subassemblies in shop and platen areas. These subassemblies were moved to the building ways as required, via railroad flat car, positioned and welded to adjoining sections. Welding techniques were developed in conjunction with the Navy's Bureau of Yards and Docks. Automatic welding played an important part in the shop fabrication of the subassemblies. Scaffolding was welded to the side walls to facilitate speed of erection.

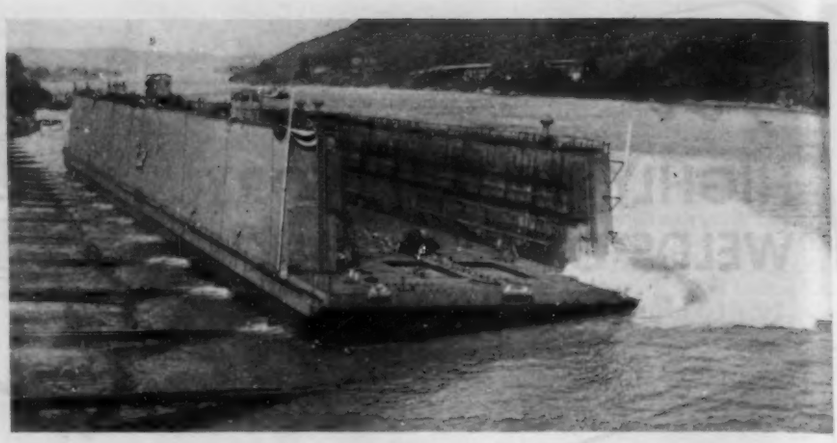

Fig. 4—ARD-33, Giant Ship-Lifting Drydock Hits the Water of the Ohio River on Saturday, Aug. 10th

The largest hull ever built on the inland rivers, the ARD-33 is 448 ft. long, 97 ft. wide and 45 ft. high. When it is completely outfitted, it will leave the yards of Dravo Corp. for a 2000-mile trek down the Ohio and Mississippi rivers and will serve the U. S. Navy Fleet as an auxiliary repair dock.

Because of its size, ARD-33 could not be launched in the conventional manner. To avoid excessive stresses that might obtain incident to launching the flat bottom of the dock was erected parallel to the sloping ways—which meant building the vessel at a slope—in this instance an angle of $1^1/_2$ in. in 12 in. As soon as the well deck was assembled, a full-revolving rail-mounted traveling crane was placed in the well, to facilitate erection of wing walls and placing of machinery.

Getting the crane aboard the vessel was an engineering job of its own, since the crane weighed 135 tons. The crane was raised 22 ft. by means of eight 50-ton jacks, and at that height was transferred.

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EFFICIENT

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Handle welded to aluminum pan with EutecRod 190. This alloy flows on aluminum like silver solder on brass—no after machining required.
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Worn armature shaft overlaid with Bronzo-Chrome 185 at 1000°F without burning the insulation or distorting the shaft. Weld is highly wear resistant, but easily machinable.
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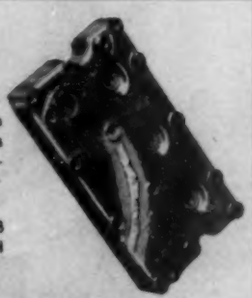

Cracked cast iron cylinder head sealed with EutecRod 15, which is applied at the amazing low heat of 354°—600°F.
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to rails laid on wood cribbing. These rails were joined to those already laid on the well deck, and the crane moved aboard under its own power. It was removed prior to launching by reversing the procedure, with the exception of the use of jacks. Coming off, the crane rode down inclined rails to ground level. The crane capacity was 30 tons at 35 ft. boom radius, and the heaviest lift on this job was approximately 25 tons. As mentioned above, the well deck sloped toward the river, while the crane, of necessity, was in a vertical position. This meant the riverside crane rail was elevated $7\frac{1}{2}$ ft. above the deck itself, with the shoreside rail snug to the deck. As construction proceeded, the crane's position—resembling a house set on a sloping plateau—excited much interest among travelers on the Pennsylvania railroad and motorists on Pittsburgh's Ohio River Boulevard. Both travel arteries carry concentrated traffic, and offered an excellent view of the building operation and the launching spectacle.

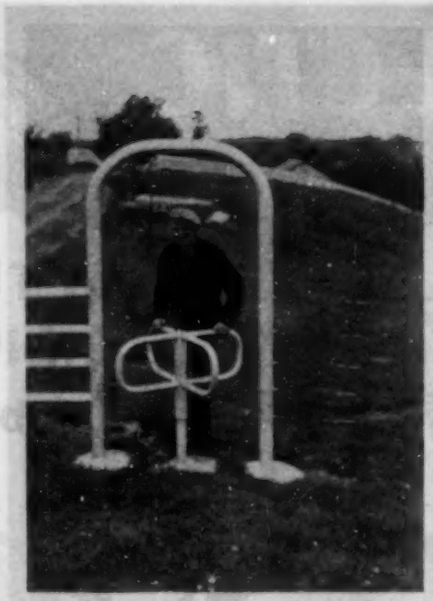
The drydock will undergo submergence tests before leaving the Dravo plant. Since the usual depths of the Ohio River in the Pittsburgh vicinity are about 16 ft. in deepest pools, it is obvious that the dock, in submerging, would rest on the river bottom before it could reach its test depth. The U. S. Army Engineers supplied the answer. They "dug a hole" in the river bottom, just above the Montgomery Dam near Rochester Pa., and there will be 45 ft. of water in the "hole"—ample for testing ARD-33. The "hole" is 500 ft. long and 150 ft. wide.

Until 1939, the Navy owned only two sizeable drydocks—the "Dewey" and ARD-1. The latter was built by Dravo Corp., and launched at its Wilmington, Del., yard. World War II brought a remarkable development in floating drydocks which enabled the fleet to operate thousands of miles from major naval bases. The Navy saw the need and embarked on a drydock construction program with the end view of keeping its fleet at maximum efficiency at all times. ARD-33 represents a part of this program.

During the last year of the war alone, more than 7000 ships were lifted out of the water by floating drydocks for repair or reconditioning. Most of these docks were located in the forward areas, and some were in the actual combat zones. Of the ships repaired, many were so badly damaged that had it not been for the fact they could be repaired on the spot they would have been sunk.

A spectacular incident demonstrating how important was the service of the floating drydocks occurred prior to the second battle of the Philippine Sea. Three major battleships which participated in that action would have been thousands of miles from the scene had it not been for these docks. Shortly before the battle, each had been given repairs which ordinarily would have necessitated time-consuming voyages back to major naval bases.

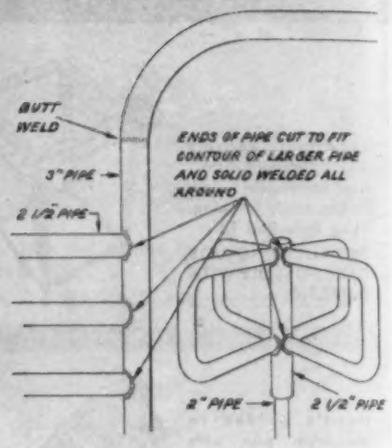
In one instance, following a Kamikaze attack, a destroyer was taken into an Auxiliary Repair Dock and given repairs while the dock was under tow.



Vern Watson, Sylvia Sunset Farms, Annandale, Minn.

HOW TURNSTILE GATE WAS BUILT

Pipe members bent to shape and welded with mild steel rod, using "Fleet-Arc Jr.", 180 ampere, welding machine for alternating current.



BENDING BY USE OF TORCH

The use of the oxyacetylene flame for bending and welding has increased production over 200% for a dragline bucket manufacturer. In addition, flame bending makes possible closer bending tolerances than could be obtained with the previous blacksmith forge method. Two men are shown heating the $1\frac{1}{4}$-in. thick steel front lip for a dragline bucket, preparatory to bending it to shape. The heating takes approximately 15 min. per side and bending is accomplished by means of a chain jack.

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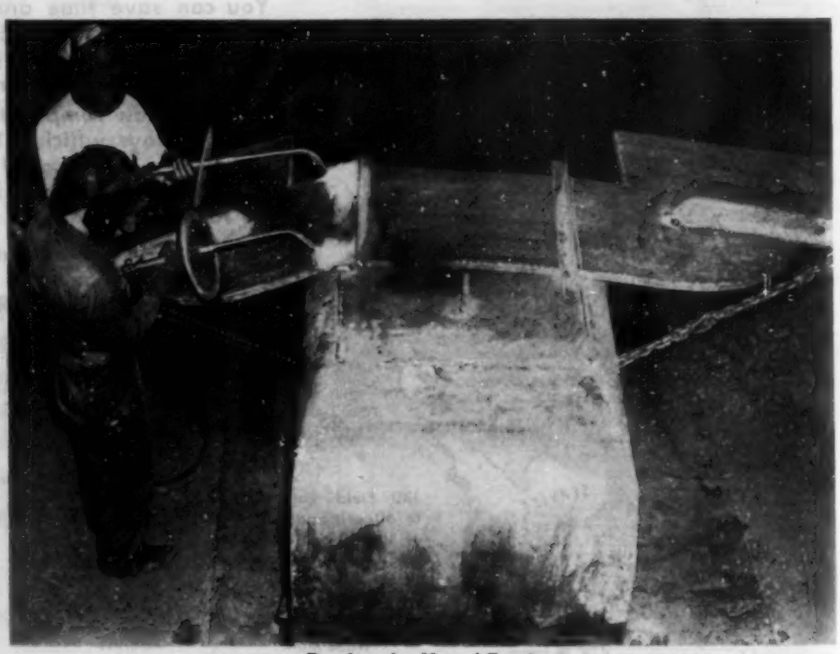
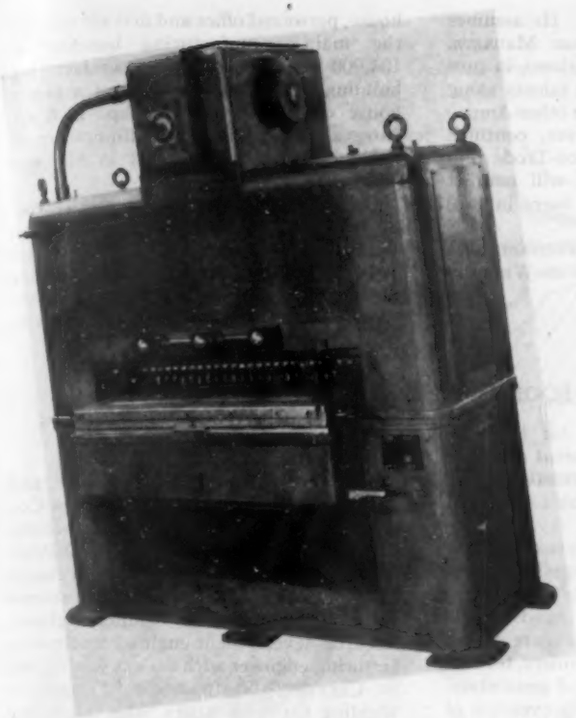
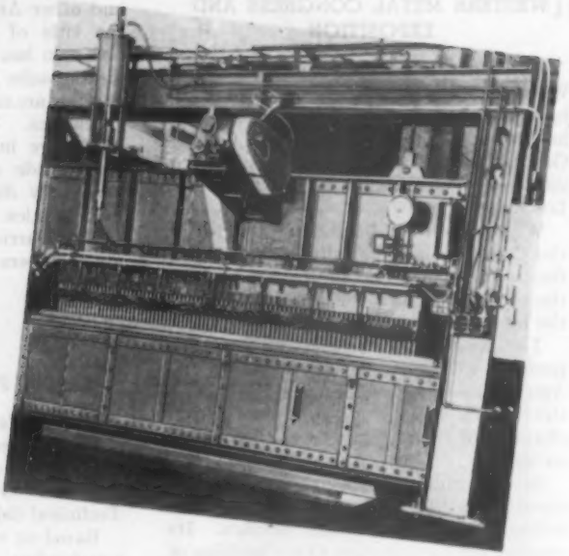


Bending by Use of Torch



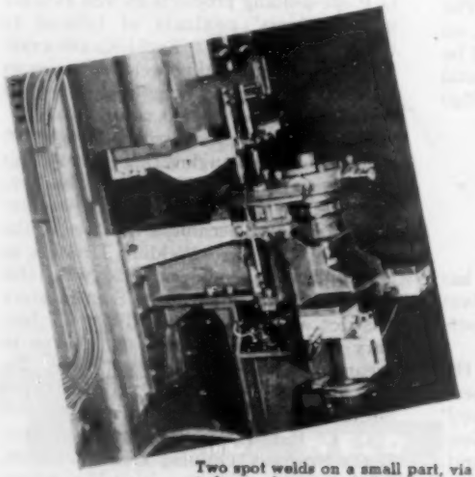
Two rows of 26 electrodes each are applied and remain under pressure while welding, assuring a flat finished assembly.



Various box car assemblies are welded in this machine which has 82 electrodes in a straight line.

A Single Purpose–with Variations

MULTIPLE-ELECTRODE spot welders, equipped with from two to one hundred or more pairs of electrodes, reduce manufacturing costs by making a multiplicity of welds in a single operation. Material handling is reduced to a minimum, distortion of the work is minimized, and welding conditions are uniform. Yet machines of this type are not necessarily limited to the spot welding of a single assembly. Each of the welders illustrated here has a considerable range of application—and every application is an outstanding example of high-speed production.



Two spot welds on a small part, via indexing fixture and double head. This type machines welds up to 2000 pieces per hour depending on the work.

Many considerations affect the choice of resistance welding equipment—and the decision to use a single high-production welder or several standard welders. Expert advice on this subject can be obtained from members of the Resistance Welder Manufacturers' Association and their field representatives. The best time to investigate the full possibilities of resistance welding is while your job is in the design or development stages.

RESISTANCE WELDER MANUFACTURERS' ASSOCIATION
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WESTERN METAL CONGRESS AND EXPOSITION

Preliminary plans for resumption of the Western Metal Congress and Exposition have been completed and the event will be held in the San Francisco-Oakland Golden Gate area for six days beginning March 22, 1947. The last such event was held in Los Angeles in 1941.

W. H. Eisenman, managing director of the Congress and Exposition, stated that the two Oakland civic auditoriums will be the scene of the fifth such gathering after the lapse occasioned by the war.

The Western Metal Congress and Exposition will again be sponsored by the American Society for Metals and will have the active cooperation of West Coast chapters of the nation's leading technical societies.

In his announcement, Mr. Eisenman stated that "the West Coast has grown industrially in leaps and bounds. Its magnificent contribution to the winning of the war has demonstrated its ability to contribute in an even greater way to the productivity of the nation. Therefore, the American Society for Metals is happy to again sponsor this event."

Technical programs of the Western Metal Congress will include lecture courses, technical papers and round-table conferences of special interest to the metals, aviation, petroleum, chemical, mining and general manufacturing industries. Further announcements of this program will be made at a later date.

In the Exposition will be shown a complete cycle of equipment and methods relating to the metals industries, including raw materials, heat-treating apparatus and supplies, inspection methods and equipment, machinery, foundry supplies, materials handling, welding and cutting, oil field equipment, small tools and finished products.

Technical sessions of the Congress and exhibits in the Exposition will be housed in the two large civic auditoriums at Oakland. The two buildings are only 125 ft. apart and are well suited to the handling of both activities.

Attendance at the 1941 Western Metal Congress and Exposition was approximately 50,000 and it is expected that the 1947 figures will exceed that total.

Floor plans are being mailed to exhibitors in former Expositions. A general distribution will be made at a later date.

NEW RESPONSIBILITIES TO SORENSEN & GARRIOTT

In addition to his duties as Development Manager for Welding Electrodes, F. E. Garriott has assumed the duties of Manager of Weldrod Sales, for Ampco Metal, Inc., Milwaukee 4, Wis. Garriott is responsible for development, production and sales of all arc welding electrodes. His practical knowledge of welding electrode research and production and sales experience will benefit weldrod distributors.

E. J. Sorensen, previously manager of Weldrod Sales, takes on more sales promotion work handling welding electrodes, and other Ampco products. He assumes the title of Sales Promotion Manager. Sorensen has had wide experience in promoting sales and his special talents along this line are needed to further other Ampco specialties. He will, however, continue his active interest in Ampco-Trode and Phos-Trode electrodes and will contact personally distributors and users in promoting sales.

Mr. Garriott and Mr. Sorenson both are members of the AMERICAN WELDING SOCIETY.

SAFETY PRECAUTIONS BOOKLET

The "do's and dont's" for handling oxyacetylene and arc equipment are carefully explained in a new manual recently compiled by Air Reduction's Railroad Technical Sales Division.

Based on many years of actual working relationship with welding operators on various railroads, this highly informative 24-page manual describes—and shows with clear illustrations—the care to be exercised when using gas cylinders, torches and regulators, hose lines and generators. Sections are also devoted to prevention of backfires and flashbacks, welding of tanks, containers and pipe lines, including notes on personal safety. Still another section is devoted to safe practices in the use of arc-welding equipment.

It is pocket sized and condensed for brief, easy reading—a "must" manual you and your co-workers will want to keep for quick reference.

For your free copy, write to Air Reduction, 60 E. 42nd St., New York 17, N. Y., or any local Airco office.

ANNUAL MEETING S.E.S.A.

The Annual Meeting of the Society for Experimental Stress Analysis including a Symposium on Telemetering of Aircraft Flight Observations will be held at The Hotel New Yorker, New York, N. Y., on Dec. 9, 10, 11, 1946. Inquiries should be addressed to the Society for Experimental Stress Analysis, P. O. Box 168, Cambridge 39, Mass.

BABCOCK & WILCOX BUYS WAR PLANT

The Babcock & Wilcox Tube Co. has purchased the welded boiler tubing plant at Alliance, Ohio, from the War Assets Administration for $1,315,794.50.

"This plant was erected in 1942 at the request of the government and has been operated since that time by the company," Peter D. White, Vice-President and General Manager of the Tube Company, said. "It was built by Babcock & Wilcox for the Defense Plant Corporation of the Reconstruction Finance Corporation. It is one of the country's largest and most modern specialty mills, and has become an important adjunct to the company."

Included in the purchase are: a two-story office building; a combination gate house, personnel office and first aid station; the main manufacturing building of 104,000 sq. ft.; another manufacturing building of 28,000 sq. ft.; and a power house containing two 284-hp. B & W Integral-Furnace Boilers. Equipment in these buildings is included in the sale price.

Construction of the plant was started in July 1942, and it was in production January 1, 1943. It was built to produce 4000 tons of $^{3}/_{4}$- to 4-in. welded tubing each month. The plant is located on Keystone St., adjacent to the B & W plant on Rush St.

I. A. CRAWFORD BECOMES VICE-PRESIDENT

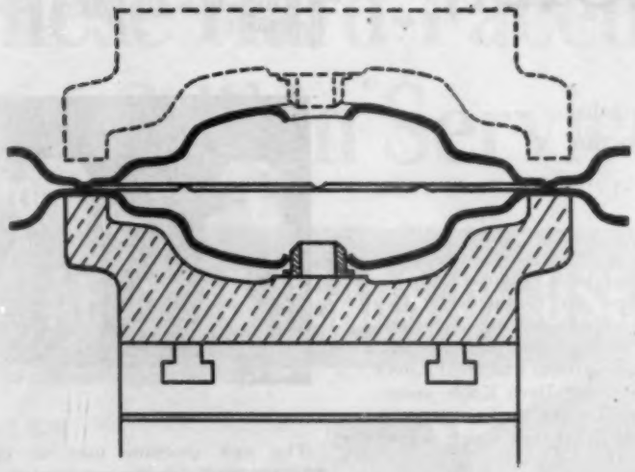
R. H. Johnson, Vice-President and Treasurer, Ex-Cell-O Steel Products Co., announces that I. A. Crawford has become associated with the Ex-Cell-O Steel Products Company as Vice-President in charge of operations. Mr. Crawford has several years of experience as welding engineer, research development engineer and manufacturing engineer with such organizations as Chrysler, Westinghouse, Progressive Welding Co. and others. Mr. Crawford will address one of the meetings of the National Metal Congress being held in Atlantic City on the subject "Design for Resistance Welding." In his association with Ex-Cell-O Steel Products Co. he will be available to assist the metal industry in the design of products and the welding methods, techniques and procedures required.

NEW G-E WELDING DIVISION BRANCH OPENS IN HOUSTON

A new branch of the G-E Electric Welding Division was recently opened in Houston, Tex., to give improved service to the welding industry in that area. Situated in a new building 60 ft. wide and 120 ft. long, the branch sells the complete line of G-E arc-welding products as well as other manufacturers' products of interest to users of arc welding. Facilities are available for demonstrating welding processes and techniques, and a completely equipped service and repair shop is maintained.

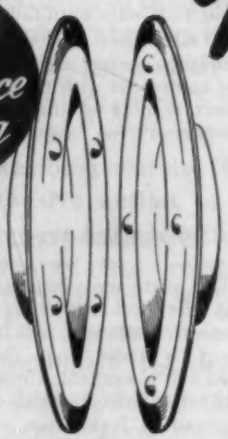
F. C. Neal, Jr., manager, received a degree in industrial engineering from Kansas University in 1936. He entered the General Electric Co.'s test course at Schenectady, and later became a member of the company's Electric Welding Division as an application engineer. He was later transferred to Dallas as Southwestern District arc-welding specialist. In January of this year he went to Houston to organize the Welding Division there. He is a member of the AMERICAN WELDING SOCIETY.

C. L. Helms, office manager, entered G-E's Business Training Course in 1928, and worked as an accountant in Schenectady until 1932, when he joined the company's Air Conditioning Dept. in Bloomfield, N. J., in a similar capacity. He was later returned to the General Office in Schenectady, and was sent to Houston in January of this year to help organize the Welding Division there.



We cut 75% off his fabricating cost

DESIGNED for Resistance Welding



Top, left... Simple ring dies are used on a Standard Progressive Projection Welder (Top, right) for fabricating steel wheels, out of two identical stampings, each with 4 projections. 8 welds are made simultaneously.

A manufacturer in Illinois was setting up to fabricate a line of toy wagons as a post-war product. He figured they could save money by making each wheel out of two identical stampings spot welded together in 8 places just below the rim.

He was right that spot welding *would* save him money and make a stronger wheel—but he did not know how much MORE he could save by a small change in the stampings.

When Progressive's engineers looked over the design they recommended that each wheel-half be provided with 4 small projections (formed during stamping—see sketch). The two halves could then be dropped into a simple fixture on a standard PROGRESSIVE PROJECTION WELDER—with the projections on one stamping half-way between the projections on the other. With this design, all eight "spots" are projection-welded simultaneously.

This simple design change cut welding and handling time down from over 11 to only 3 seconds per wheel. Desired output of 1200 wheels per hour could now be obtained with one man and one Projection Welder instead of 4 men operating 4 Rocker-Arm Spot Welders.

PROGRESSIVE engineers will be glad to save you money, too, by studying your design for lower cost resistance-welding.

For news of the latest developments in resistance welding equipment and methods, influencing product design, ask to be put on the mailing list for the Progressive "WELDING PICTORIAL".

IT PAYS TO WELD

PROGRESSIVE Welder Co.

"SEE US AT THE METALS SHOW" Booth J-220

3050 E. OUTER DRIVE • DETROIT 12

RESISTANCE WELDING EQUIPMENT

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

ALL-POSITION ELECTRODE

The new Airco No. 87 electrode is a general purpose, mild steel electrode operating exceedingly well on d.-c. straight or reverse polarity and on a.-c. producing a weld metal of high mechanical properties. It is especially recommended for low-cost, single- or multiple-pass welding on plates or sections where the fit-up is poor, or the work is rusty or dirty.

Based on extensive research, this new extruded-coated rod embraces not only the most satisfactory characteristics of other electrodes in its class but also incorporates the best tested results in its long development. Electrode No. 87 is a highly satisfactory rod for work involving welding of mild steel with poor fit-up.

Now available in quantities, this improved electrode offers many advantages. Briefly enumerated, the following points emphasize the most outstanding benefits to the operator:

1. Capable of producing excellent welds over wide current ranges for any given diameter.
2. This electrode is outstanding in that the performance characteristics are substantially the same when using d.-c. straight polarity, d.-c. reverse polarity or a.-c.
3. Excellent results are obtained in all positions.
4. Has exceptionally high deposition rate.
5. Has very high deposition efficiency.
6. Arc action is such that the less skilled operators can produce excellent results at high speeds even on lighter gage metals.
7. Conforms to A.W.S. Classification E-6012 and is marked in accordance with N.E.M.A. standards.

Although the new electrode's applications are numerous in varied industries particularly where welding of poor fit-up is to be successfully accomplished, some specific uses are: storage tanks, steel structures, sections of hopper and boxcars, ducts and ventilating equipment and general maintenance and repair work in railroad shops, foundries, etc.

Further information on this new development is available on request from Air Reduction Sales Co., 60 E. 42d St., New York City 17, or through any of its district offices.

ELECTRIC EYE HELPS BUILD STREAMLINERS

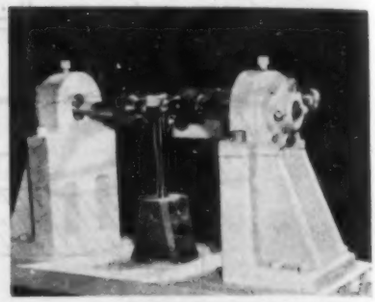
Electric eye arrangement is unique feature of new multiple spot welder developed by Pullman-Standard engineers to increase streamline car production. Two rows of holes, drilled close together along entire side of a movable bed, activate battery of welding electrodes when bed moves into proper position. Herb Koch, assistant welding engineer for the company, is shown removing small pins which permit

electric eye ray to pass through from below the bed and complete contact with electric eye units shown in background just above the row of holes. An almost unlimited number of combinations can be worked out, making the machine entirely automatic.

NEW FATIGUE MACHINE

A new instrument which fatigues parts such as turbine buckets, small assemblies and test specimens by reverse bending has been announced by the Special Products Division of the General Electric Co. Using a pneumatic resonant principle, the new machine vibrates the specimen undergoing test at its own resonant frequency, and closely simulates the actual dynamic loading conditions.

The machine is one basic unit consisting of a fatigue motor. An optional accessory panel providing recording and direct reading or displacement, frequency and temperature of the specimen, as well as automatic shutdown upon failure of the specimen, can be added at any time. A furnace which permits testing at temperatures up to 1700° F. is also offered as optional equipment.



The new machine uses an opposed cylinder-type driving mechanism to vibrate the specimen. The specimen is positioned so that when small lightweight pistons are attached to it, the pistons are located between the openings of the two opposed cylinders. Air pressure is turned on, and pressure impulses from the cylinders vibrate the specimen. By adjusting the driving mechanism until the frequency of the pressure impulses is the same as the natural frequency of the specimen, highest displacement of vibration is obtained. The machine will continue to vibrate until failure occurs.

A microscope and vibrating-type reed frequency meters are furnished as standard equipment with the fatigue motor for direct reading of displacement and frequency.

STAINLESS STEEL FITTINGS

One of the most complete lines of stainless steel welding fittings to reach the postwar market is now being manufactured by Tube Turns (Inc.), Louisville, Ky., and is available through distributors located in all principal cities, it is announced by Jack Green, sales manager of the firm's Welding Fittings Div. The line includes 180° long radius returns, 90° long radius elbows, 45° long radius elbows, straight tees, reducing outlet tees, caps, eccentric reducers, concentric reducers, lap joint stub ends, laterals and crosses, all in standard and extra heavy weights; and welding neck flanges, slip-on flanges, threaded flanges, blind flanges, socket-type welding flanges, reducing flanges, orifice flanges and lap joint flanges. Sizes range from ¾ through 12 in.

The fittings may be had in three grades of stainless steel; Type 304, containing 18% chromium and 8% nickel; type 347, containing 18% chromium, 8% nickel and approximately 1% columbium; and type 316, containing 18% chromium, 8% nickel and 2% molybdenum. Surveys conducted by Tube Turns' Engineering Service Dept. and other research groups indicate that these grades meet 95% of industry's standard requirements.

The introduction of Tube Turns' complete line of stainless steel welding fittings

These Hard-Faced Mixer Blades Are Still in Service

AFTER 5 YEARS OF USE

This cast-steel mixer blade was hard-faced with HAYNES STELLITE No. 6 welding rod. Protected areas include the leading edge of the 26-in. blade and the stuffing box bearing, 6 in. in diameter.

These hard-faced cast-steel blades—used to mix an unusually abrasive rubber compound—are still out-to-size and in good operating condition after more than 5 years of service.

Before they were protected by a welded-on coating of abrasion-resistant HAYNES STELLITE alloy, the abrasive action of the compound caused the edges and the bearing surfaces of the blades to wear away after a relatively short time. The service life of the unit was approximately 8 months. Hard-facing the blades eliminated the down-time previously required for frequent replacement and, by maintaining operating efficiency at a high level for a long period of time, has brought substantial savings.

It pays to use hard-facing with HAYNES alloys to protect new parts before they are worn, also to reclaim worn parts and protect them against further wear. Write for your copy of "Hard-Facing Materials Data" . . . there is no charge.

A view of the two mixer blades as installed in the 100-gal. mixing tank. After 5 years these blades are still out-to-size and in good working conditions. Unfaced blades lasted about 8 months.

HAYNES TRADE-MARK *alloys*

Haynes Stellite Company

Unit of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Chicago — Cleveland — Detroit — Houston — Los Angeles — New York — San Francisco — Tulsa

The registered trade-marks "Haynes" and "Haynes Stellite" distinguish products of Haynes Stellite Company.

gives the users two sets of advantages, each of which reinforces the other. They are:

1. The inherent advantages of stainless steel itself. It resists atmospheric corrosion, acids and chemicals. It resists scaling at high temperature, and is strong and ductile at subzero and elevated temperatures. It has long life, reduces maintenance cost, virtually eliminates contamination and has a clean and attractive appearance.
2. The advantages inherent in all piping systems fabricated with Tube-Turn fittings, whether of stainless steel, carbon steel, Monel, brass, copper or other metals. These are: leak-proof joints, less weight, minimum flow resistance, lower upkeep, greater strength and safety, more flexibility and streamlining.

Tube Turns originated and introduced the first welding fittings, in 1927, making what is regarded as the greatest single contribution to the efficiency of modern industrial and marine piping.

Tube-Turn fittings, including those of stainless steels, are forged by a patented process. The result is a close-grained, uniform metal structure with no locked-in residual stresses.

HARD-FACING ELECTRODE

Stoody Co., manufacturers of hard-facing alloys, announces the new improved Coated Stoody Self-Hardening, a wear resistant electrode for hard-facing all heavy equipment subjected to earth abrasion and impact. Coated Stoody Self-Hardening differs from the former "dipped type" electrodes in a new extruded flux coating which improves welding characteristics and simplifies application.

Coated Stoody Self-Hardening is a fabricated rod consisting of mild steel tubes filled with alloying elements. The new coating is applied to the rod by means of an hydraulic extrusion press which greatly increases strength over dipped coatings and materially reduces tendency to pick up moisture. Above all, coatings are completely uniform. Outstanding advantages of the new Stoody Self-Hardening are as follows:

1. Excellent arc characteristics with either a.-c. or d.-c. machines.
2. No slag interference.
3. More rapid deposition rate than dipped electrodes.
4. Can be welded in all positions.
5. No loss of hardness or wear resistance on multiple layers.
6. Solid, dense deposits with an absolute minimum of porosity.
7. Satisfactory application within a wide range of amperages.
8. Easy slag removal while deposit is still red hot. Slag is self-lifting when deposits cool.
9. Any desired type of bead can be applied including stringers, figure eights, crescents, weaving beads, etc.

Hardness ratings of the new flux-coated, Stoody Self-Hardening deposits average 56 on the Rockwell "C" Scale. The melting point remains at 2525° as before, and the specific gravity is 7.80.

In addition to high wear resistance and toughness the new Coated Stoody Self-Hardening can be forged without loss of hardness, providing forging is done at red heat. Deposits bond well with manganese steel and its use is especially recommended on wearing surfaces of all heavy equipment made from this metal.

Because of its toughness and resistance to abrasion the new Coated Stoody Self-hardening provides maximum wear protection on all equipment subject to earth abrasion and impact, such as power shovel and tractor parts, muller tires, crushers of all types, pump impellers, steel mill wabblers, etc.

A new circular provides complete information and will be sent free of charge.

HUGE SPOT WELDER UPS PRODUCTION 3000%

Development of a new huge multiple spot-welding machine, one of the largest of its type known in existence today, has been announced by Pullman-Standard Car Manufacturing Co.

The new machine is in operation at the Company's Car Works plant in Chicago where welding engineers say it will increase production in the department about 30 times, or 3000%, over present processes.

Weighing more than 90,000 lb. the huge machine was built for Pullman-Standard by National Electric Welding Machines Co. of Bay City, Mich. It was developed after extensive study of all existing methods by development engineers of both Pullman-Standard and the builders.

The machine will be used primarily to weld "stiffeners" to the interior of car sides to give them the sleek appearance dictated by today's flashy colored streamliners. Engineers explain that a "stiffener" is not visible, but is a sheet of light gage corrugated metal which is welded inside the walls of the car to lend strength and smoothness, much on the same principle as the corrugation on the interior of a cardboard box, making it many times more sturdy than the wall alone.

The use of corrugated stiffeners in car building was patented by Pullman-Standard in 1938 and the first system of fabrication employed single, stationary spot welders making one weld at a time. These were used until 1942, when the war suspended all car building. The principle of applying multiple spot welding to this work was developed during the war period and with the advent of postwar car building the new machine was built.

In operation, a metal table 30 ft. long and 10 ft. wide travels beneath a battery of 48 stationary welding electrodes. The work to be welded is laid flat on the table, which has been covered with a copper plate. As the table moves slowly beneath the row of spot-welding electrodes it is adjusted to stop at proper intervals and the electrodes automatically lower, making contact with the work and securely welding the "stiffeners" to the car side. The electrodes then lift up and the table moves on to the next position, where the process is completed.

A unique electric eye arrangement makes the operation entirely automatic. Along one side of the table are drilled two rows of small holes about a 1/4 in. apart. The electric eye beam is directed from beneath the table, through these holes, and when striking a photoelectric cell above the holes, the circuit is completed which stops the table, lowers the electrodes, makes the weld, lifts the electrode and starts the table into operation again.

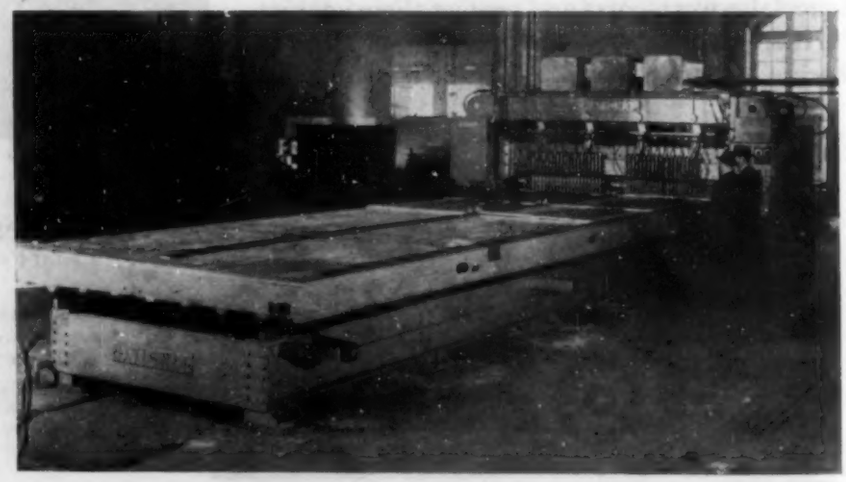
By dropping loose rivets into all the holes not needed in the operation, the position of welding is preset. The table then moves along smoothly until an open hole passes over the light ray, setting the welding process into operation.

GIANT PORTABLE SPOT WELDER FOR STRUCTURAL STEEL

Several versions of this huge portable machine have recently been built and shipped by Sciaky Bros., Inc., of Chicago, to help rebuild war-torn Russia.

The welders are capable of welding up to three thicknesses of 1/2-in. structural steel without removing the rust and scale usually present on this material. Application is primarily for speeding prefabrication of large structural units in ships.

Other uses include mass production of large assemblies in railroad, marine, truck



Electrodes, Wires, Fluxes

for welding MONEL · NICKEL · INCONEL

MONEL

Oxy-Acetylene	"40" Monel Gas Welding Wire	For welding Monel, using INCO "1" Gas Welding and Brazing Flux
Oxy-Acetylene	"43" Monel Gas Welding Wire	For welding heavy sections of Monel for acid pickling service — no flux required
Metal-Arc	"130X" Monel Welding Electrode D.C.	For welding Monel; and Monel or Nickel to steel
Submerged Melt.	"50" Monel Wire	For welding Monel

NICKEL

Oxy-Acetylene	"41" Nickel Gas Welding Wire	For welding of pure Nickel — no flux required
Metal-Arc	"131" Nickel Welding Electrode D.C.	For welding pure Nickel
Submerged Melt.	"51" Nickel Wire	For welding pure Nickel

INCONEL

Oxy-Acetylene	"42" Inconel Gas Welding Wire	For welding Inconel, using INCO "2" Gas Welding Flux
Metal-Arc	"132" Inconel Welding Electrode A.C.-D.C.	For welding Inconel; and Inconel to steel
Submerged Melt.	"52" Inconel Wire	For welding Inconel

70/30 COPPER-NICKEL

Oxy-Acetylene	"47" 70/30 Copper-Nickel Gas Welding Wire	For welding 70/30 Copper-Nickel using INCO "1" Gas Welding and Brazing Flux
Metal-Arc	"137" 70/30 Copper-Nickel Welding Electrode D.C.	For welding 70/30 Copper-Nickel
Submerged Melt.	"57" 70/30 Copper-Nickel Wire	For welding 70/30 Copper-Nickel

"K" MONEL

Oxy-Acetylene	"44" "K" Monel Gas Welding Wire	For welding "K" Monel, using 2 parts INCO "2" Gas Welding Flux and 1 part Lithium Fluoride
Metal-Arc	"134" "K" Monel Welding Electrode D.C.	For welding "K" Monel

"L" NICKEL

Metal-Arc	"136" Nickel Welding Electrode D.C.	For welding "L" Nickel

LUKENS

NICKEL-CLAD STEEL

Metal-Arc	"131" Nickel Welding Electrode D.C.	For welding Nickel side only

"L" NICKEL-CLAD STEEL

Metal-Arc	"136" Nickel Welding Electrode D.C.	For welding "L" Nickel side only

MONEL-CLAD STEEL

Metal-Arc	"130X" Monel Welding Electrode D.C.	For welding Monel side only

INCONEL-CLAD STEEL

Metal-Arc	"133" 80/20 Nickel-Chromium Welding Electrode A.C.-D.C.	For welding Inconel side only; and solid Inconel to steel

FLUXES

INCO "1" Gas Welding and Brazing Flux — For the welding and brazing of Monel and other nickel-copper alloys; copper and copper-nickel.

INCO "2" Gas Welding Flux — For the welding of all stainless steels, rustless irons, Inconel and other chromium-containing alloys.

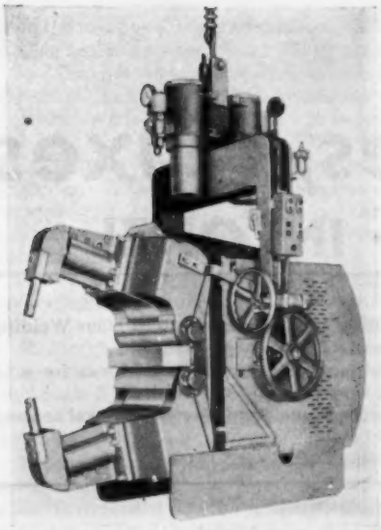
CAST IRON WELDING

Metal-Arc	"NI-ROD" Electrode A.C.-D.C.	For machinable welds in cast iron

For additional information or assistance on use of Inco electrodes, wires and fluxes, address Technical Service, The International Nickel Co.

NICKEL INCO **ALLOYS**

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York 5, N.Y.



and bus shops, where parts may be joined by overlapping or flanges.

Welding through the rust and scale is accomplished by a special electronically controlled sequence which provides (1) a preweld period of high pressure and low current which burns off oxide, allows perfect fit of parts and reduces electrode tip deterioration, (2) a high-current welding period during which electrode pressure is reduced for greater efficiency, and (3) a postweld period which retains the high current under high pressure to prevent coarse structure and internal cracks. Current is interrupted and high pressure retained for a final forging action.

Where high-carbon steels (above 0.20%) are to be welded, a special quench and postheat period is provided which effectively eliminates the hardening caused by welding high-carbon material.

The high current demand and distribution facilities normally required when welding such heavy gages is materially reduced by employment of the Sciaky "Three-Phase" principle. This system not only constitutes a three-phase balanced load, but also permits operation at near unity power factor at a greatly decreased kilovolt-ampere demand. Peak power demand when welding the maximum thicknesses ($^1/_2 + ^1/_2 + ^1/_2$ in. or $^5/_8 + ^5/_8$-in. is only around 500 kva.)

Consistently sound welds on a production basis were obtained, with resistance to shear of single spots on $^5/_8$- + $^5/_8$-in. structural steel well above 37 tons. Speed is from 2 to 25 spots per minute, depending upon thickness and degree of scale. Machine may be either suspended from crane or pedestal mounted.

Detailed bulletins on both the machines and the "Three-Phase" principle supplied upon request.

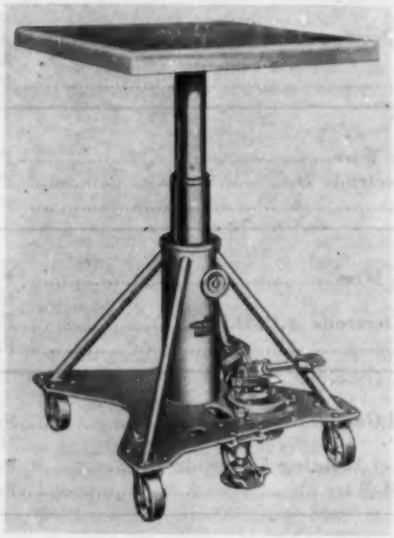
PORTABLE HYDRAULIC ELEVATING TABLE

Because of frequent demands for a range of elevation not obtainable with standard construction, LYON-Raymond Corp. have developed a telescopic cylinder for their Hydraulic Elevating Table.

This telescopic cylinder makes possible an elevating range from 28 to 50 in. or a total lift of 22 in. The strength and rigidity of the central column have not been lessened.

In the handling of dies, jigs and fixtures, the telescopic table permits leveling with press beds and storage racks allowing for easy transfer. The greater range of elevation is also valuable when the table is used in assembly operations and as a transfer member in a conveyor line.

Except for cylinder and guide sleeves, standard elevating table parts are used. Optional extras which were developed for the standard table are available also for the telescopic table. These include two-speed foot pump, demountable roller top,



telescopic towing handle, die separator, indexing device and retaining bars.

LYON-Raymond Corp., 2866 Madison St., Greene, N. Y.

ALL-POSITION ELECTRODE

Now available in quantity, the new improved No. 107 electrode is the result of estensive research in extruded coatings and is probably the most satisfactory rod on the market for work involving poor fit-up on mild steel. It is especially recommended for single or multiple pass welding on rusty or dirty plates or sections. This versatile, low-cost electrode embraces excellent arc characteristics, working equally as well on d.-c. straight or reversed polarity as on a.-c.

Briefly enumerated, the following points emphasize the outstanding benefits for the operator: (1) Can be used with abnormally high welding current. (2) Has exceptionally high deposition rates. (3) Permits use of "dragging technique." (4) Excellent appearance of weld deposit is immediately observed. (5) Has more forceful arc action. (6) Offers high burn-off rate.

Although the new electrode's applications are numerous in varied industries wherever welding of poor fit-up is to be successfully accomplished, some specific uses are: welding sections of hopper and box cars, scaling flues in boilers and general maintenance and repair work in railroad shops as well as repairing structural assemblies, foundry and ventilating equipment and storage tanks.

Rod conforms to the E-6012 classification of the A.W.S. Specification A233-45T and is marked in accordance with N.E.M.A. standards.

Additional information concerning this new development is available on request from Wilson Welder and Metals Co., Inc., 60 East 42nd St., New York 17, N. Y., or through the offices of local distributors.

SPOT WELDERS

Banner Products Co. is announcing a new line of bench-type spot welders, the first of which is a 1-kva., manually operated unit (illustrated).

This welder is ideal for light gage material, and is at present being used on such diverse applications as the welding of copper wire to Inconel strips on heating elements, mild steel wire to mild steel strips on accordians, and mild steel wire frames for lamp shades.

The frame is of high-strength cast aluminum designed to allow ample ventilation for the transformer. The latter is air cooled with a laminated copper secondary of sufficient cross section to allow for high overload capacity. Three ranges of heat regulation are supplied.

The welder has a maximum stroke of 1 in., and a throat depth of $3^1/_4$ in. It is supplied with a rugged foot pedal, and weighs 46 lb.

LIGHTWEIGHT LADDERS

Lightweight ladders that last a lifetime, of all-welded magnesium construction, are now being manufactured by White Aircraft Corp., of Palmer, Mass. Their 8-ft. magnesium ladder weighs only $5^1/_2$ lb. as compared to 16 lb. in wood, while the weight of a 63-lb., 24-ft. extension ladder has been cut to 31 lb. Permanent strength, safety and rigidity are said to be additional features of these ladders. All-metal construction avoids splintering and deterioration due to weather exposure. Welding of the rungs into the side channels assures complete freedom from the loosened joints which make a ladder wobbly and unsafe.

A complete line of household and industrial ladders is scheduled for production. Their lightness and durability should make them valuable to individuals and firms who appreciate these qualities in their manually handled equipment.

HIGH INTENSITY SOFT X-RAYS THE MACHLETT AEG-50

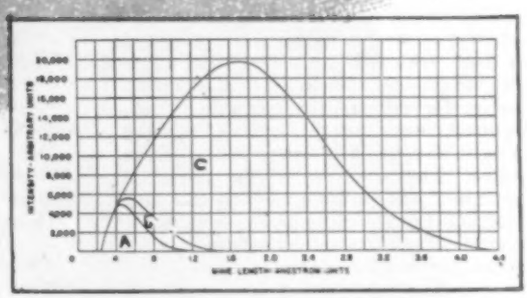
THIS is an announcement of a new Machlett X-ray tube that provides soft X-rays in high intensity. The wave band covered extends from .2475 to 4.4 Angstrom units. See chart.

APPLICATIONS. Microradiography, industrial radiography and fluoroscopy of light materials, and other uses requiring high-intensity soft X-radiation. Examples: Inspection of thin sheets and wires, and of welds in them.

RATINGS. Maximum Voltage: 50 PKV, useful or inverse. Anode at ground potential. Maximum Energy: 20 MA at 50 PKV continuous.

GENERAL. Water-cooled by tap water flowing through ducts in vacuum-cast copper anode. Rayproof. May be operated on either rectified or unrectified voltage. Available in either shockproof or non-shockproof form.

For complete details of this new tube, write Machlett Laboratories, Inc., Springdale, Connecticut.



Wave bands and intensities of X-ray provided through: A, aluminum; B, pyrex glass; C, beryllium

WARNING!

Due to the low inherent filtration of the beryllium window of this tube, its very close proximity to the focal spot, and the high milliamperage rating, the intensity of the radiation at the outer surface of the window may be as high as 1,000,000 R Units per minute. Adequate precaution to avoid the possibility of any person being exposed to this unfiltered radiation, even for an instant, must be taken.

A 50 MA version of this tube offers new possibilities for research on the photochemical effects of X-radiation at intensities in excess of 2,000,000 R Units per minute. Inquiries are invited.

MACHLETT

APPLIES TO INDUSTRIAL USES ITS 49 YEARS OF ELECTRON-TUBE EXPERIENCE

ABSTRACTS OF CURRENT WELDING PATENTS

Prepared by V. L. Oldham

Printed copies of patents may be obtained for 25¢ from the Commissioner of Patents, Washington 10, D. C.

2,404,423—Method and Apparatus for Protecting Burners—James L. Anderson, inventor, Closter, N. J., assignor to Air Reduction Co. (8 Claims)

This method relates to the prevention of accumulation on a burner of spatter from a work piece and it comprises interposing a perforated plate between the burner and the work piece, and continually producing a sheet of liquid on the work piece side of the plate.

2,404,437—Electrode Holder—Thomas S. Donnelly, Jr., inventor, Detroit, Mich., assignor to Bordon Mfg. Co., Inc. (3 Claims)

This patented holder has a metallic electrode gripping member and a support member. A flexible electric conducting member connects the support member to an associated metallic connector member that is adapted to connect to an electric conductor.

2,404,620—Control of Flash Welding—Joseph H. Cooper, inventor, Warren, O., assignor to The Taylor-Winfield Corp. (10 Claims)

This patent relates to electric-flash-butt welding apparatus having a movable and a fixed work holding platen with a hydraulic cylinder, controlled by a follow-up valve, for moving the movable platen. A direct current motor is provided to move a movable control element of the follow-up valve. The armature of the motor is energized in opposite directions and with controlled intensity by means including a pair of controlled electric discharge devices connected in inverse parallel relation.

2,404,632—Electric Resistance Welding Apparatus—Hans H. Hansen, inventor, Warren, O., assignor to The Taylor-Winfield Corp. (15 Claims)

The welding apparatus has a supporting structure that carries a transformer and has an electrode mounting arm extending therefrom and having a roller electrode thereon. The work piece is relatively movable with relation to the structure. The roller electrode is slidably mounted on the arm and means are associated with the electrode to move it with relation to its mounting arm so that the electrode may have intermittent motion with respect to its mounting arm as such arm continuously moves with relation to the work.

2,404,857—Fastener for Positioning, Aligning, and Securing Plates for Welding—Roy W. McLaren, inventor, Oaklyn, N. J.; Helen H. McLaren, administratrix of said Roy W. McLaren, deceased, assignor to Helen McLaren. (3 Claims)

In this patent, a fastener bracket for use in adjustably aligning and temporarily securing complemental ship plates in position for permanent welding action is disclosed.

2,405,177—Stud Welding—John Collier Beckett, inventor, United States Navy. (6 Claims)

This patent covers a welding device including a casing, foot means attached to the casing, and means in the casing for supporting a flat-headed pin the point of which is to be welded to an article.

The pin support means are adapted to engage with the pins, are movable in the casing, and are specially associated with the foot means.

2,405,406—Welding Rod Holder—George A. Combridge, inventor, Los Angeles, Calif. (6 Claims)

The patented holder has a tubular electrode in its handle and a tubular core is movable in the electrode for engaging with welding rods. Then a toggle lever connects to the core and engages with a pressure plate on the outer surface of the handle for controlling the core's position.

2,405,510—Electric Welding Apparatus—Daniel C. Maytag, inventor, Laurel, Ia. (6 Claims)

The patented apparatus is for welding successive links of a chain together and it has a pair of adjustable gripping members for applying a controlled pressure to the links during the welding operation.

2,405,536—Electrode Holder—Martin Wells, inventor, Los Angeles, Calif. (10 Claims)

This novel electrode holder has a metal body with a rod opening formed therein and means inside the body for forcibly engaging the end of a rod inserted into the opening. A replaceable insulator member is slidably carried by the metal body.

2,405,542—Fusion Welding—Frank A. Wassell, inventor, Schenectady, N. Y., assignor to General Electric Co. (12 Claims)

Wassell's welding process is for metal parts which, when molten, do not intermingle readily to form a weld. It comprises abutting the edges of two members so that they make good contact at the top but are spaced apart at their bottoms, heating the top edges to melt them, and supplying molten filler material to fill the gap between the parts to weld them together.

2,405,666—Welding—Stanley M. Norwood, inventor, Great Neck, N. Y., assignor to Electro Metallurgical Co. (9 Claims)

The patent covers a welding rod made of a substantially austenitic iron-chromium-nickel alloy. The alloy is made from 10 to 30% chromium, 4 to 30% nickel, 0.5 to 7% manganese, 0.05 to 0.25% vanadium, 0.01 to 0.5% carbon and the remainder iron, fluxing materials and incidental impurities.

2,405,673—Electric Welding—Egon B. Scheri, inventor, New York, N. Y., assignor to The Linde Air Products Co. (3 Claims)

The patent relates to the deposit of metal from an electrode and coalescing it with the base metal, wherein an electric melting current is passed through the electrode and base with a gap being maintained there between. The patent's novelty consists in applying supplemental heat to the electrode to increase the ratio of melted electrode metal to melted base metal.

2,405,828—Apparatus for Arc Welding—William C. Huguley, inventor, Belleville, N. J. (4 Claims)

In this patent, a work-receiving chamber is provided and it has a pair of electrodes adjustably positioned in it. Means are provided for moving work in the chamber with relation to such electrodes. Then other means envelope the electrode ends in a hydrogen atmosphere which is sealed from the room in which the chamber is located.

2,406,076—Apparatus for Determining Weldability—Julius Heuschkel, inventor, Mount Lebanon, Pa., assignor to Carnegie-Illinois Steel Corp. (2 Claims)

The patented apparatus is for testing the strength of a test piece that is held in the apparatus and a movable member is provided for applying a variable but measured force to the test piece. Then a scale

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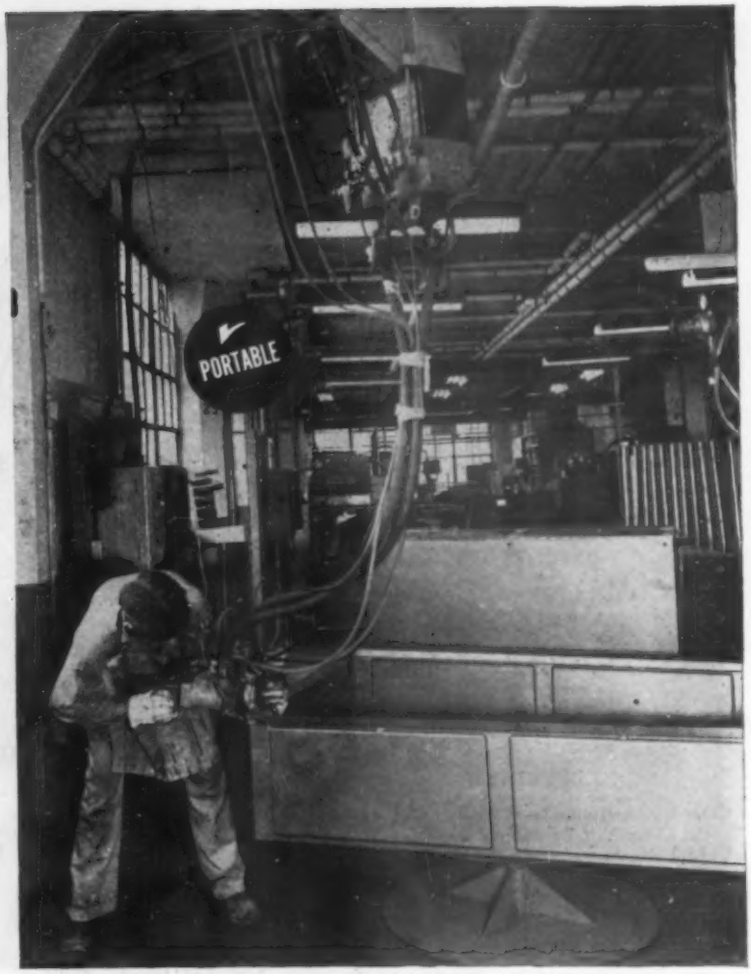

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is associated with such movable member and adapted to indicate the pressure exerted thereby and to generate an energy-absorption curve during the test of the test piece.

2,406,092—AUXILIARY EYESHIELD AND WELDING HOOD—Roger E. Meyer, inventor, St. Paul, Minn. (4 Claims) The patented hood has a separate eye shield, with both the hood and shield being pivotally mounted on a head harness. Resilient means are associated with the mounting means to resist pivotal movement of the hood or shield.

List of New Members

August 1 to August 31, 1946

BRIDGEPORT

Smith, Thomas G. (C), 75 Factory St., Ansonia, Conn.

CHICAGO

Stanick, Herman A. (C), Chicago Bridge & Iron Co., 1305 W. 105th St., Chicago 43, Ill.

CLEVELAND

Carman, Lawrence G. (C), 31013 W. Lake Rd., Bay Village, Ohio.
Goldstein, H. R. (C), Burdett Oxygen Co., 3300 Lakeside Ave., Cleveland, Ohio.
Oberst, John (C), 47 Browning Ct., Berea, Ohio.
Stewart, James Brock (B), Pittsburgh Steamship Co., 614 Superior Ave. N. W., Cleveland 13, Ohio.

DAYTON

Brown, Carl E. (C), 217 E. Canal St., Troy, Ohio.
Hirsch, Marvin K. (C), Hobart Bros. Co., Troy, Ohio.
Howe, Neil (B), Acme Spring & Welding, 527 E. Second St., Dayton 2, Ohio.
Little, John E. (B), 534 W. Stewart St., Dayton, Ohio.
McCoy Wendell (C), 66 Vincent St., Dayton 5, Ohio.
Mumma, Emerson (B), Mumma & Sidenstick, 1501 Springfield St., Dayton, Ohio.
Rish, Fred (B), Acme Spring & Welding, 527 E. Second St., Dayton 2, Ohio.
Scott, Robert F. (C), 924 Lincoln Ave., Troy, Ohio.
Swanson, Norman R. (C), 219 S. Short St., Troy, Ohio.

DETROIT

Crutcher, Henry B. (C), 16629 Stansbury, Detroit 21, Mich.
Dawn, George L. (C), 3600 Buno Rd., Milford, Mich.
Foote, William A. (B), Kolene Corp., 315 Boulevard Bldg., Detroit 2, Mich.
Mack, George F. (C), 6891 Rutherford Ave., Detroit 10, Mich.
Metcalf, Fred D. (C), Ford Motor Co., Village Rd., Plant, Dearborn, Mich.
Palid, Joseph James (C), Box 118, 113 Clarence St., Belleville, Mich.
Pfander, William J. (B), Ford Motor Co., Chemical Eng. Gate 4, Dearborn, Mich.
Wright, Everett G. (C), Patent Attorney, 1015 Fisher Bldg., Detroit 2, Mich.

HARTFORD

Bogacki, Benjamin J. (B), 59 Mayflower St., Elmwood, Conn.
Janeski, Joseph S. (C), Whitlock Mfg. Co., Hartford, Conn.
Powell, Marselis (B), Whitlock Mfg. Co., Hartford, Conn.

INLAND EMPIRE

Brosinska, Ray E. (B), W. 1215 Mallon Ave., Spokane, Wash.
Kulp, O. B. (B), Route 1, Spokane, Wash.
Palm, E. W. (B), N. 5824 Lincoln St., Spokane, Wash.

LOS ANGELES

Eubank, Howard C. (C), 11814 S. Orchard Ave., Los Angeles, Calif.
Reno, Robert W. (C), P. O. Box 272, Torrance, Calif.

MAHONING VALLEY

Baker, Michael N. (C), 533 Wilson St., Sharon, Pa.
Duncan, James T. (C), Youngstown Welding & Engrg. Co., 3700 Oakwood Ave., Youngstown, Ohio.
Lyon, Harry E. (C), Westinghouse Elec. Corp., 25 E. Boardman St., Youngstown, Ohio.
Purnell, Theodore A. (C), 546 W. Myrtle Ave., Youngstown, Ohio.
Walters, Robert D. (C), R. D. 2, Kirk Rd., Canfield, Ohio.

NEW JERSEY

Dusche, John G. (C), Acorn Welding Service, 265 Passaic St., Newark, N. J.
Johnsen, William K. (B), 1148 Weber St., Union, N. J.
Krauth, Carl F., Jr. (C), Acorn Welding Service, 265 Passaic St., Newark, N. J.
Lyons, Joseph B. (C), Jersey Welding Supply, 343 E. 3rd St., Plainfield, N. J.
Shanley, Joseph B. (C), Jersey Welding Supply, 343 E. 3rd St., Plainfield, N. J.

NEW ORLEANS

Simmons, C. L. (B), P. O. Box 1368, New Orleans, La.

NEW YORK

McGhee, Wesley M. (C), 459 Main St., Farmingdale, N. Y.
Serra, Julius H. (C), 88 Quinlan Ave., Staten Island 2, N. Y.
Strawbridge, Maynard A. (B), 3307 Hull Ave., Bronx 67, N. Y.

NORTHERN NEW YORK

Pearl, Martin (C), Pearl Auto Wrecking, Box 88, Margaretville, N. Y.

NORTHWEST

Hauskey, Henry L. (A), Crown Iron Wks. Co., 1229 Tyler St., N. E., Minneapolis, Minn.
Horn, Henry H. (B), Universal Milling Machine Co., Albert Lea, Minn.
Moody, Alfred J., Jr. (B), 2219 Fifth Ave. S., Minneapolis 4, Minn.
Moorhead, John K. (B), 927 Second Ave. S.E., Minneapolis 14 Minn.
Ovestrud, Melvin (A), 1515 Central Ave., Minneapolis 13, Minn.

NORTHWESTERN PA.

Jarski, Joseph T. (C), 248 E. 2nd St., Erie, Pa.

PHILADELPHIA

Schattel, K. F. (B), National Cylinder Gas Co., 1614 Summer St., Philadelphia 3, Pa.
Walker, Kenneth M. (C), 24 Franklin Ave., Philadelphia 18, Pa.

PITTSBURGH

Barnes, Orville K., Jr. (B), P. O. Box 111, E. Pittsburgh, Pa.
Baumgarten, Francis J. (B), 11 Esther Ave., Carrick, Pittsburgh 10, Pa.
Beatty, Hanford T. (C), Dravo Corp., Neville Island, Pittsburgh 25, Pa.
Chang, Steven C. (C), Central Electrical Mfg. Wks. of China, 7137 Penn Ave., Pittsburgh, Pa.
McCutcheon, Donald R. (C), 7236 McClure Ave., Swissvale, Pittsburgh 18, Pa.

ROCHESTER

Odenbach, Robert C. (C), Odenbach Shipbldg. Corp., 4800 Dewey Ave., Rochester, N. Y.
Ward, Charles F. (C), 210 Lark St., Rochester 13, N. Y.

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Rich, Stuart L. (B), Welding Consultant, 528 White Bldg., Buffalo 2, N. Y.

WICHITA

Rundell, I. Boyd (B), Felten Welding Supplies, 328 N. 13th, Salina, Kan.

NOT IN SECTIONS

Backhouse, Thomas H. M. (B), c/o British Oxygen Co., Ltd., Gelderd Rd., Weeds 12, Yorkshire, England.

Boyle, Leo W. (B), International Harvester Co., East Moline Wks., 11th Ave. & 3rd St., E. Moline, Ill.

Brandenberger, Oscar (B), 187, Langstrasse, Zurich 5, Switzerland.

Faltus, Professor F., Ing.Dr. (B), Institute of Steel Const., Prague 11, Trojanova 13, Czechoslovakia.

Hancke, Gunnar (B), A-S Esab, Trekronergade 92, Kobenhavn, Valby, Denmark.

Naulty, Reginald (C), c/o Hume Steel Ltd., Subirco, Western Australia.

Nielsen, Christian (C), Strandmollen, Spring Forbi, Copenhagen, Denmark.

Norlin, Per V. (B), c/o A B Motala Verkstad, Motala Verkstad, Sweden.

Ramon, Bolivar C. (C), A Monterey Co. S. A., Casilla 312, Santiago, Chile.

Robson, Stanley (C), 56 Thornfield Rd., Linthorpe, Middlerbrough, Yorkshire, England.

Torre, Pier Luigi (C), Innocenti, Via Pitteri 81, Milano.

Walton, Ronald N. (C), c/o 24, Birch St., Wolverhampton, Staffs, England.

Members Reclassified

During Month of August

CLEVELAND

Yarrow, Ross J. (from C to B), 1324 Irene Rd., Lyndhurst, Ohio.

NORTHWEST

Hall, Edgar E. (from C to B), Flour City Welding Co., 2937—3rd Ave. S., Minneapolis 8, Minn.

NEW JERSEY

Rush, Harold W. (from C to B), Marvin St., R. F. D., Dover, N. J.

NEW YORK

Giles, Herbert (from C to B), 70-01—113th St., Forest Hills, N. Y.

NORTHERN NEW YORK

Westbrook, Jack H. (from F to C), R. F. D. 3, Pinewood Ave. Rd., Troy, N. Y.

PHILADELPHIA

Spofford, William P. (from C to B), Dravo Corp., Wilmington 99, Del.

PITTSBURGH

Atwood, G. H. (from C to B), Maple St. Extension, R. D. 2, Coraopolis, Pa.

Dawson, A. J. (from C to B), Dravo Corp., Neville Island, Pittsburgh 25, Pa.

Willison, Ernest (from C to B), 1125 Greentree Rd., Pittsburgh 20, Pa.

YORK-CENTRAL PA.

Lee, Richard K. (from C to B), 521 Colonial Ave., York, Pa.

SECTION ACTIVITIES

DETROIT

The first meeting of the season held by the Detroit Section was in the form of a plant inspection trip to the Progressive Welder Co. on Friday, September 13th, at 8 P.M. Those attending saw Resistance Welding at work and what it can do. Spot, projection, press, seam and flash welders were displayed and typical resistance-welding applications were demonstrated. A Stored Energy Battery Welder, the newest innovation in resistance welding, was the feature display of the meeting. Refreshments were served.

The first meeting of the season of the Saginaw Valley Division was held on Thursday, September 12. Dinner at the Zehnder's Hotel, Frankenmuth, Mich., preceded the meeting. "Application of Electronics in Today's World" was discussed by R. F. Roberts of the Industrial Tube Div., Westinghouse Electric Corp. From Atomic Energy to Welding with emphasis on Radar and Radio, electronic tubes are the valves controlling production. Mr. Roberts displayed the latest of these devices and discussed their application and use in the world of today.

INDIANA

The following officers were elected for the coming year by the Indiana Section at a meeting held in May:

Chairman, James R. Neff, P. R. Mallory & Co.; *1st Vice-Chairman*, R. F. Smith, Delco-Remy Div., General Motors; *2nd Vice-Chairman*, Karl H. Kick, Citizens Coke & Utility Co.; *Treasurer*, Paul F. Grubbs, P. R. Mallory & Co.; *Secretary*, Mrs. Mercedes Spotts, P. R. Mallory & Co.; *Program Chairman*, R. F. Smith; *Membership Chairman*, Karl H. Kick.

WESTERN MASSACHUSETTS

A meeting of members and representative group from the various industries in the Springfield area was held on Wednesday, August 28th. Those attending were dinner guests of the Gilbert and Barker Mfg. Co., West Springfield, Mass., at their plant.

The following officers and directors were elected for the 1946–47 season:

Chairman, Joseph A. Tinsman, Gilbert & Barker Mfg. Co.; *Vice-Chairman*, Sydney Lowe, Chapman Valve Co.; *Secretary*, A. Labossiere, Chapman Valve Co.; *Treasurer*, H. Walsh (re-elected), Worthington Pump Co. *Directors;* John J. Jones, Emil Stolte, R. W. Gamache, R. Pearsall, Gordon Clark and F. W. Taft. *Program Committee*, J. A. Powell, Emil Stolte, Harold Wrigley; *Publicity* J. Witkop

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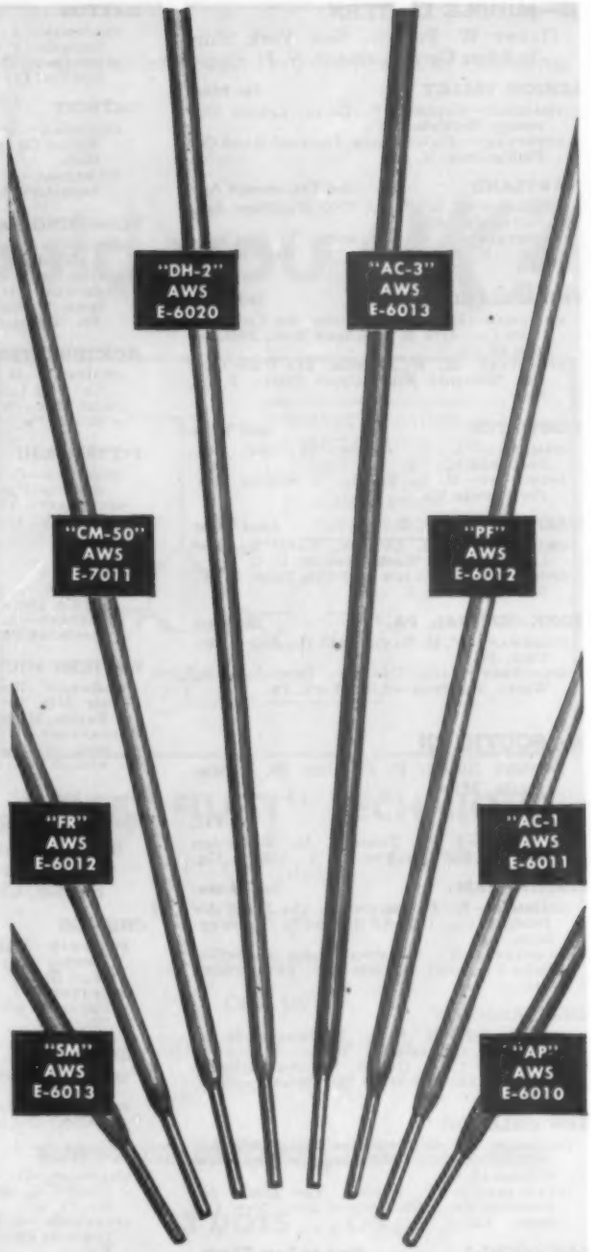

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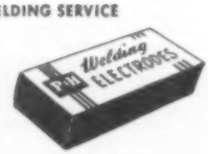

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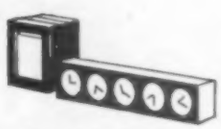
WELDING POSITIONERS



WELDING PRODUCTION CONTROL SYSTEMS

ELECTRIC HOISTS

#2—MIDDLE EASTERN

HARRY W. PIERCE, New York Shipbuilding Corp., Camden, N. J.

LEHIGH VALLEY — 1st Mon.
CHAIRMAN—GILBERT E. DOAN, Lehigh University, Bethlehem, Pa.
SECRETARY—JULIUS NAAB, Ingersoll-Rand Co., Phillipsburg, N. J.

MARYLAND — 3rd Fri. except Apr.
CHAIRMAN—J. W. GORE, 3707 Woodbine Ave., Baltimore, Md.
SECRETARY—A. C. EARLBECK, T. A. Canty, Inc., 1023 Cathedral St., Baltimore 1, Md.

PHILADELPHIA — 3rd Mon.
CHAIRMAN—HAROLD B. SEYDEL, Air Reduction Sales Co., 17th & Allegheny Ave., Philadelphia 40, Pa.
SECRETARY—K. W. OSTROM, 213 Glen Gary Dr., Westgate Hills, Upper Darby P. O., Pa.

TIDEWATER — 2nd Tues.
CHAIRMAN—A. C. BERGH, 27 Gay Ave., Portsmouth, Va.
SECRETARY—H. R. FLOYD, 14 Benton Ave., Portsmouth Va.

WASHINGTON, D. C. — Last Tues.
CHAIRMAN—G. G. LUTHER, Naval Research Lab., Bellevue, Washington 20, D. C
SECRETARY—A. PILTCH 1445 Otis Place, N. W., Washington, D. C.

YORK-CENTRAL, PA. — 1st Wed.
CHAIRMAN—W. C. BAUER, 335 Harding Court, York, Pa.
SECRETARY—PAUL DRESSEL, Dressel Spring Works, 325 Prospect St., York, Pa.

#3—SOUTHERN

SYDNEY SWAN, P. O. Box 58, Pascagoula, Miss.

ATLANTA — 1st Fri.
SECRETARY—J. D. TURNER, Air Reduction Sales Co., 336 Spring St., N. W., Atlanta, Ga.

BIRMINGHAM — 1st Thurs.
CHAIRMAN—W. B. BROWNING, The Linde Air Products Co., 1001-13 S. 22nd St., Birmingham, Ala.
SECRETARY—W. L. POOLE, Air Reduction Sales Co., 2825 N. 29th Ave., Birmingham, Ala.

CHATTANOOGA*
CHAIRMAN—H. H. PEEK, Lookout Boiler & Mfg. Co., Chattanooga, Tenn.
SECRETARY—G. G. GREEN, National Cylinder Gas Co., 1329 Chestnut St., Chattanooga 2, Tenn.

NEW ORLEANS†
CHAIRMAN—G. O. STILWELL, Gulf Welding Equipment Co., 1133 Magazine St., New Orleans 13, La.
SECRETARY—R. P. WILSON, The Linde Air Products Co., 832 Howard Ave., New Orleans, La.

PASCAGOULA — Next to Last Thurs.
CHAIRMAN—DOW RIPLEY, Ingalls Shipbuilding Corp., Pascagoula, Miss.
SECRETARY—L. G. WEBER, 722 Washington Ave., Pascagoula, Miss.

#4—CENTRAL

C. O. HOGLUND, The Aluminum Co. of America, New Kensington, Pa.

CINCINNATI — 4th Tues.
CHAIRMAN—LARRY E. SHERMAN, Box 183, Lockland P. O., Cincinnati 15, Ohio
SECRETARY—ROBERT F. MARTIN, 3732 Andrew Ave., Cincinnati, Ohio

CLEVELAND — 2nd Wed.
CHAIRMAN—KENT C. THORNTON, The American Shipbuilding Co., 1410 Terminal Tower, Cleveland 13, Ohio
SECRETARY—J. F. WAGNER, American Welding Society, 3300 Lakeside Ave., Cleveland 14, Ohio

COLUMBUS — 2nd Fri.
CHAIRMAN—R. W. SHACKLETON, 2854 Dresden Ave., Columbus 3, Ohio
SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

DAYTON
CHAIRMAN—A. J. MEALY, Air Reduction Sales Co., P. O. Box 923, Dayton, Ohio
SECRETARY—D. H. RICKARD, Andrew Plocher Son Co., 424 E. First St., Dayton, Ohio

DETROIT — 2nd Fri.
CHAIRMAN—ALFRED H. LEWIS, Swift Electric Welder Co., 6560 Epworth Blvd., Detroit 10, Mich.
SECRETARY—E. B. BROWN, 2804 Trafford Rd., Royal Oak, Mich.

MAHONING VALLEY — 3rd Thurs.
CHAIRMAN—A. L. WILLIAMS, Federal Machine & Welder Co., 390 Griswold St., Warren, Ohio
SECRETARY—H. ROSS STROBECKER, Youngstown Welding & Eng. Co., 3700 Oakland Ave. Youngstown, Ohio

NORTHWESTERN, PA.
CHAIRMAN—W. H. COCHRAN, General Electric Co. East Lake Rd. Erie, Pa.
SECRETARY—W. R. BOYD, 160 E. 8th St., Erie 1, Pa.

PITTSBURGH — 3rd Wed.
CHAIRMAN—G. O. HOGLUND, Aluminum Co. of America, New Kensington, Pa.
SECRETARY—J. F. Minnotte, Minnotte Bros. Co., 1201 Housel Bldg., Hays 7, Pittsburgh, Pa.

TOLEDO — 2nd Tues.
CHAIRMAN—J. C. GEISLAND, City Auto Stamping Co. Lint & Dura Aves., Toledo, Ohio
SECRETARY—A. H. HOMRIGHAUS, JR., 2734 Powhatan Parkway, Toledo 6, Ohio

WESTERN MICHIGAN — Last Mon.
CHAIRMAN—WM. H. SLAUGHTER, Prop., Slaughter Mfg. Co., 3753 Division Ave., Grand Rapids, Mich.
SECRETARY—R. DUDLEY LAYMAN, Pres., Layman Welding Supply Co., 1000 Ottawa Ave. N. W., Grand Rapids, Mich.

#5—MID-WESTERN

R. E. MCFARLAND, Dept. 7866, Western Electric Co., Inc., Hawthorne Station, Chicago 23, Ill.

CHICAGO — 3rd Fri.
CHAIRMAN—HARRIS A. GOODWIN II, Bastian-Blessing Co., 4201 W. Peterson Ave., Chicago, Ill.
SECRETARY—T. B. JEFFERSON, The Welding Engineer, 506 S. Wabash Ave., Chicago 5, Ill.

INDIANA — 4th Fri.
CHAIRMAN—JAMES R. NEFF, 2630 Ryan Drive, Indianapolis, Ind.
SECRETARY—MRS. MERCEDES SPOTTS, P. R. Mallory Co., Indianapolis, Ind.

LOUISVILLE — 4th Tues.
CHAIRMAN—G. W. PLINKE, Henry Vogt Machine Co., 10th & Ormsby Sts., Louisville, Ky.
SECRETARY—R. E. MORRISON, Kentucky Metal Products Co., 3104 S. Preston St., Louisville, Ky.

MICHIANA
CHAIRMAN—G. C. HILL, 1441 Chester St., South Bend 15, Ind.
SECRETARY—W. G. FASSNACHT, Bendix Prods. Div., Bendix Aviation Corp., South Bend 20, Ind.

MILWAUKEE — 4th Fri.
CHAIRMAN—G. F. MEYER, Machinery Welder Corp., 3623 W. National Ave., Milwaukee 4, Wis.
SECRETARY—CHAUNCY HART, Hart Engineering & Sales Co., 2015 W. Clybourn Ave., Milwaukee, Wis.

NORTHWEST — 1st Wed.
CHAIRMAN—R. H. NEWTON, The Lincoln Electric Co., 206 Sexton Bldg., Minneapolis 15, Minn.
SECRETARY—ALEXIS CASWELL, Manufacturers' Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis, Minn.

PEORIA-CENTRAL ILLINOIS — 3rd Wed.
CHAIRMAN—HAROLD BALDWIN, 116 Steven St., Peoria, Ill.
SECRETARY—GERALD W. PLANE, Caterpillar Tractor Co., % Training Bldg., Peoria, Ill.

#6—MID-SOUTHERN

HOWARD N. SIMMS, 1217 S. W. 32, Oklahoma City, Okla.

DENVER
CHAIRMAN—G. H. GARRETT, Thompson Pipe & Steel Co., Larimer at 30th St., Denver, Colo.
SECRETARY—M. W. EDDY, Thompson Pipe & Steel Co., Larimer at 30th St., Denver, Colo.

KANSAS CITY — 1st Tues.
CHAIRMAN—A. C. SLUSS, Moore Co., 556 Rd., Kansas City, Mo.
SECRETARY—WM. J. SNIDER, 4105 E. 37th St., Kansas City 3, Mo.

OKLAHOMA CITY — 1st Thurs.
CHAIRMAN—CHARLES M. BOWEN, Lincoln Electric Co., Box 5006, Oklahoma City, Okla.
SECRETARY—L. L. STEWART, Welders Supply Co., Box 653, Oklahoma City, Okla.

ST. LOUIS — 2nd Fri.
CHAIRMAN—GAYDEN DERICKSON, % Shell Oil Co., Inc., Wood River, Ill.
SECRETARY—A. PANDJIRIS, Pandjiris Weldment Co., 5151 Northry Ave., St. Louis 10, Mo.

SOUTH TEXAS — 3rd Thurs.
CHAIRMAN—T. J. KEGG, Champion Rivet & Supply Co., 447 Esperson Bldg., Houston 2, Tex.
SECRETARY—W. H. GREER, Box 175, Houston, Tex.

TULSA‡
CHAIRMAN—JAMES G. MCILHINEY, P. O. Box 590, Tulsa, Okla.
SECRETARY—JAMES B. DAVIS, Tulsa Testing Labs., Tulsa, Okla.

WICHITA§
CHAIRMAN—MARCEL L. LAMPTON, 2312 N. Minnesota, Wichita, Kans.
SECRETARY—H. W. Beeman, 1360 Perry St., Wichita, Kans.

#7—WESTERN

C. P. SANDER, Western Pipe & Steel Co. of Calif., 5717 Santa Fe Ave., Los Angeles, Calif.

HAWAII — Last Thurs.
CHAIRMAN—GEORGE GLOVER, W. A. Ramsay, Ltd., Honolulu, T. H.
SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., Box 2454, Honolulu, T. H.

INLAND EMPIRE
CHAIRMAN—THOMAS S. SHOLES, N. 5615 Monroe, Spokane 12, Wash.
SECRETARY—ELLSWORTH L. REYNOLDS, Spokane Blacksmith & Welding Wks., 1502 E. Trent, Spokane 15, Wash.

LONG BEACH
CHAIRMAN—V. M. GOODE, 262 Covina Ave., Long Beach 3, Calif.
SECRETARY—GEO. DUNCAN, 1501 Branco Court, Channel Heights, San Pedro, Calif.

LOS ANGELES — 3rd Thurs.
CHAIRMAN—DAVID BISBEE, Norris Stamping Co., 5215 S. Boyle Ave., Vernon, Calif.
SECRETARY—E. O. WILLIAMS, Victor Equipment Co., 3821 Santa Fe. Ave., Los Angeles 11, Calif.

PORTLAND, ORE.
CHAIRMAN—PAUL KULLBERG, Industrial Specialties Co., 940 S. E. 7th Ave., Portland 14, Ore.
SECRETARY—J. H. GRUMLEY, Western Machine Corp., 816 S. E. Taylor St., Portland, Ore.

PUGET SOUND — 4th Tues.
CHAIRMAN—PROF. G. S. SCHALLER, University of Washington, Seattle 5, Wash.
SECRETARY—H. O. VAN SLYKE, Air Reduction Sales Co., 3623 E. Marginal Way, Seattle 4, Wash.

SAN FRANCISCO — 4th Mon.
CHAIRMAN—MARK HAINES, Mark Haines Welding Shop, P. O. Box 457, Santa Rosa, Calif.
SECRETARY—R. E. LABAGH, Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.

TACOMA
CHAIRMAN—ELMER GUNETTE, 3615 N. 22nd Street, Tacoma 7, Wash.
SECRETARY—BUD OHLER, Bud's Welding Supply & Repair Service, 944 Market St., Tacoma 3, Wash.

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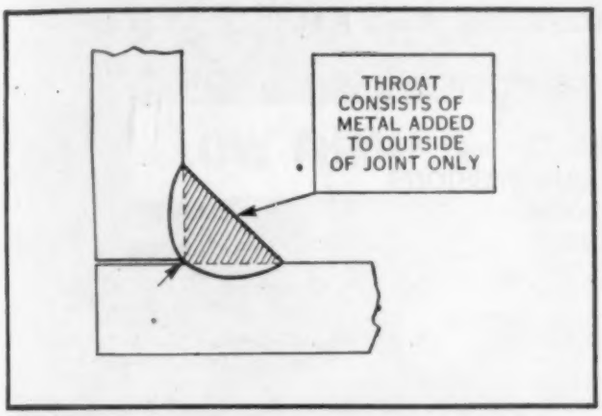
* Chattanooga—on first Friday of month, except January. Then it will be on the 10th.
† New Orleans—Jan. 7, Jan. 30, Mar. 4 (attempting to arrange meeting for April 4th).

‡ Tulsa—Jan. 11, Feb. 8, Mar. 8, Apr. 5, May 10, June 7.
§ Wichita—Jan. 9, Feb. 6, Mar. 6, Apr. 3, May 8, June 5.

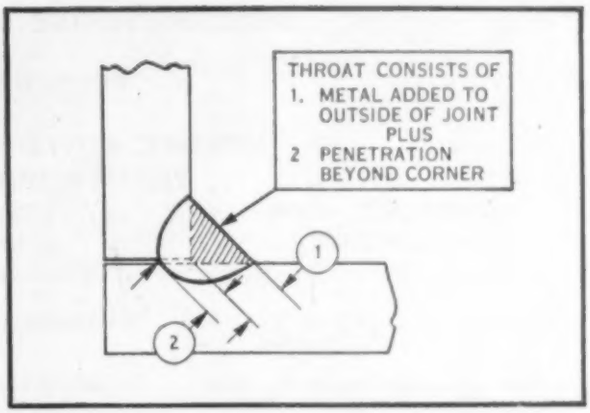
Apply Draja's reasoning **to the choice between two methods of welding mild steel . . . fillets for example:**

Which would you *OK*?



CONVENTIONAL METHOD

½" plate
¼" "Fleetweld 11"
300 amps.
one pass
Speed: **5" per min.**
Cost: **100%**



"FLEET-FILLET" TECHNIQUE

½" plate
¼" "Fleetweld 11"
350 amps.
one pass
Speed: **12" per min.**
Cost: **42%**

The Lincoln Engineer nearby will gladly help you apply "Fleet-Fillet" and other "Fleet-Welding" procedures to *your* specific problems. Handy pocket manual, Bul. 444, free on request.

3 DOTS . . . OK.

This trademark identifies genuine "Fleetweld" Electrode . . . the world's leader for *low cost, speed* and *quality*.

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America's greatest natural **recourse**

ARC WELDING

TENTATIVE PROGRAM

AMERICAN WELDING SOCIETY
TWENTY-SEVENTH ANNUAL MEETING
WEEK OF NOVEMBER 17, 1946

THE AMBASSADOR, ATLANTIC CITY, N. J.

SUNDAY EVENING, NOVEMBER 17th, 5 to 7 P.M.
CLUB 22
PRESIDENT'S RECEPTION

MONDAY, NOVEMBER 18th, Morning—9:30 A.M.
THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
WELDABILITY

Chairman—GILBERT E. DOAN
Lehigh University

Vice-Chairman—CLARENCE E. JACKSON, Union Carbide & Carbon Res. Labs.

Cracking and Ductility in the Heat-Affected Zone of Metal Arc Welds
by C. B. VOLDRICH, Battelle Memorial Institute

An Investigation of the Effect of Welding on the Transition Temperatures of Navy High Tensile Low-Alloy Steels
by G. G. LUTHER, R. E. METIUS, C. E. HARTBOWER and F. H. LAXAR, Naval Research Laboratory

Influence of Geometrical Restraint and Temperature on the Toughness and Mode of Rupture of Structural Steel
by A. R. ANDERSON and A. G. WAGGONER, Cramp Shipbuilding Cpor.

VENETIAN ROOM
ELECTRODES

Chairman—J. H. DEPPELER,
Metal & Thermit Corp.

Vice-Chairman—J. H. HUMBERSTONE,
Arcrods Corp.

The E601X Electrode Group
by ORVILLE T. BARNETT, Metal & Thermit Corp.

Some Recent Developments in the Manufacture of Fluxes for Automatic Submerged Arc Welding
by DR. WILLI M. COHN, Consulting Engineer and Physicist

Development and Application of Lime Ferritic Electrodes
by D. L. MATHIAS and A. P. BUNK, Metal & Thermit Corp.

CLUB 22
RAILROAD

Chairman—A. G. OEHLER,
Assoc. Editor, Railway Age

Vice-Chairman—J. W. SHEFFER,
American Car and Foundry Co.

Quantity Production of Railroad Passenger Cars by Resistance Welding
by A. M. UNGER, Pullman-Standard Car Manufacturing Co.

Locomotive Boilers—Welded Construction
by JAMES PARTINGTON, American Locomotive Co.

Welded Freight Car Construction
by R. L. REX, Air Reduction

OPENING METALS EXPOSITION—12 Noon

Monday Afternoon—2:00 P.M.
THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
RESEARCH

Chairman—G. E. CLAUSSEN,
Chairman, University Research Committee

Vice-Chairman—MARVIN SEDAM,
Alloy Rods Co.

Arc Atmospheres and Underbead Cracking
by M. W. MALLETT and P. J. RIEPPEL, Battelle Memorial Institute

The X-Ray Diffraction Study of the Effect of Residual Compression on the Fatigue of Notched Specimens
by J. T. NORTON, D. ROSENTHAL and S. B. MALOOF, Massachusetts Institute of Technology

The Weldability of Ship Steels: Effects of Travel Speed, Preheat Temperature, and Arc Power Level on Notch Toughness
by ERNEST E. NIPPES and WARREN F. SAVAGE, Rensselaer Polytechnic Institute

Some Observations on the Weldability of High Strength Wrought Aluminum Alloys
by W. R. APBLETT, Naval Research Laboratory

VENETIAN ROOM
PRODUCTION

Chairman—J. J. CHYLE,
A. O. Smith Corp.

Vice-Chairman—F. J. WHITNEY, JR.,
Heintz Manufacturing Co.

Automatic Gas Shielded Welding
by G. J. GIBSON, Air Reduction Sales Co.

Jigs and Fixtures for Automatic Fusion Welding
by L. J. BERKELEY, Penn Tool and Machine Co., and E. D. MORRIS, The Linde Air Products Co.

Tool and Die Welding
by A. R. BUTLER and FRANK E. KESSLER, Welding Equipment & Supply Co.

Welding of Electric Apparatus
by E. F. POTTER, Works Laboratory, General Electric Co.

CLUB 22
STORAGE TANKS AND PRESSURE VESSELS

Chairman—H. O. HILL,
Bethlehem Steel Co.

Vice-Chairman—HARRY IRRGANG,
W. K. Mitchell Co.

Field Erected Pressure Vessels
by FRED L. PLUMMER, Hammond Iron Works

Dry Seal Gas Holders, All-Welded
by RUDOLF KRAUS, Stacey Bros. Gas Construction Co.

Submerged-Melt Welding in Pressure Vessel Fabrication
by N. G. SCHREINER, The Linde Air Products Co.

REVERE No. 456 "Flame Tested" bronze welding rod

HERE is a bronze welding rod that welders like to work with. Not only because Revere No. 456 is a genuine low fuming rod, but because it is a time-saver for all kinds of maintenance and repair work. In the bronze welding of cast and malleable irons, wrought iron, cast and wrought steel, cast and wrought bronze, it provides quick, strong, dense welds. As an extra check on its performance, Revere No. 456 is "Flame Tested" before shipment.

Other Revere Welding Rods include Revere Bronze 380; Revere Manganese Bronze; Herculoy; Revere Phosphor Bronzes; Revere Brass (Brazing Rod); Revere Silicon Deoxidized Copper; Revere Phosphor Deoxidized Copper; and Revere Electrolytic Copper. They come in 100-pound cases or in 25-pound cartons, net weight, and are handled by Revere Welding Rod Distributors in all parts of the country. Write for folder giving technical data and net prices.

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230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

* * *

Listen to *Exploring the Unknown* on the Mutual Network every Sunday evening, 9 to 9:30 p. m., EST.

Monday Evening—8:00 P.M.

RENAISSANCE ROOM
ADAMS' LECTURE

Chairman—J. D. GORDON, Progressive Welder Co.

Vice-Chairman—W. G. THEISINGER, Lukens Steel Co.

Lecture by DR. WENDELL F. HESS, Rensselaer Polytechnic Institute

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TUESDAY, NOVEMBER 19th, Morning—9:30 A.M.
THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
RESEARCH

Chairman—CHARLES H. JENNINGS, Westinghouse Electric Corp.

Vice-Chairman—GEORGE G. LUTHER, Naval Research Laboratory

Computation of Cooling Time in Butt Welds
by D. ROSENTHAL, Massachusetts Institute of Technology

Effect of Peening on Residual Welding Stresses
by E. PAUL De GARMO, FINN JONASSEN and J. L. MERIAM, University of California

Welding of High Strength Steels with Ferritic Electrodes
by S. A. HERRES and P. E. WOODWARD, Watertown Arsenal Laboratory

VENETIAN ROOM
RESISTANCE WELDINC

Chairman—R. E. POWELL, Western Electric Co.

Vice-Chairman—B. L. WISE, National Electric Welding Machines Co.

Flashwelding of Concentrated Areas Up to 24 Sq. Inches in SAE 1020, NE 9440, and NE 8620 Steels
by D. BRUCE JOHNSTON, McPhee and Johnston

Resistance Welding of Spring Steel to Low Carbon Steel
by ARTHUR WILLINK, Registered Professional Engineer

Design for Resistance Welding
by I. A. CRAWFORD, Ex-Cell-O Steel Products Co.

CLUB 22
MACHINERY

Chairman—L. S. McPHEE, Whiting Corp.

Vice-Chairman—A. J. RAYMO, Baldwin LocomotiveWorks

The Metallurgical Effect of Flame Hardening Application
by O. M. HARRELSON, Georgia School of Technology

The Evolution of Diesel Engine Block Weldment Designs
by JAMES W. OWENS, Fairbanks-Morse & Co.

Coordination of Engineering and Production in the Manufacture of Welded Products
by E. C. BREKELBAUM, Harnischfeger Corp.

Tuesday Afternoon—2:00 P.M.

THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
RESEARCH

Chairman—JOHN W. GORE, Bethlehem Steel Company, Baltimore Yard

Vice-Chairman—H. L. INGRAM, JR., Air Reduction Sales Company

Redistribution of Residual Welding Stresses by Tensile Loading Along a Unionmelt Weld Joining Two 3 Ft. x 12 Ft. x 1 In. Plates.
by J. L. MERIAM, E. PAUL DeGARMO and FINN JONASSEN, University of California

Welding Research as Applied in the South
by W. W. AUSTIN, JR. and E. N. KEMLER, Southern Research Institute

Welding of Hardenable Steels with High-Alloy (Austenitic) Electrodes
by MISS A. M. TURKALO and CAPT. S. A. HERRES, Watertown Arsenal Laboratory

An Investigation of the Phenomenon of Cleavage Type Fractures in Low-Alloy Structural Ship Steels
by H. J. GERSHENOW and G. G. LUTHER, Naval Research Laboratory

VENETIAN ROOM
RESISTANCE WELDING

Chairman—R. T. GILLETTE, General Electric Company

Vice-Chairman—GEORGE N. SIEGER, S-M-S Corp.

Resistance Welding with Storage Battery Power
by JOHN D. GORDON, Progressive Welder Co.

A Summary of the Spot Welding of High Tensile Carbon and Low-Alloy Steels
by W. D. DOTY and WYLIE J. CHILDS, Rensselaer Polytechnic Institute

Selecting Spotwelding Schedules for Low Carbon Steel
by JULIUS HEUSCHKEL, Westinghouse Electric Laboratories

CLUB 22
SHIPBUILDING

Chairman—H. W. PIERCE, New York Shipbuilding Corp.

Vice-Chairman—T. M. JACKSON, Sun Shipbuilding & Dry Dock Co.

Some Problems of Welding Design and Fabrication of Steel Floating Dry Docks
by A. AMIRIKIAN, Bureau of Yards and Docks, Navy Department

Control of Welding Stresses by Welding Sequence
by PAUL FFIELD, Shipbuilding Division, Bethlehem Steel Co.

Discussion—Final Report of the Board to Investigate the Design and Methods of Construction of Welded Steel Merchant Vessels
by COMDR. R. D. SCHMIDTMAN, J. LYELL WILSON, and FINN JONASSEN, Members of the Sub-board

---

Tuesday Evening—8:00 P.M.

ROOM 125

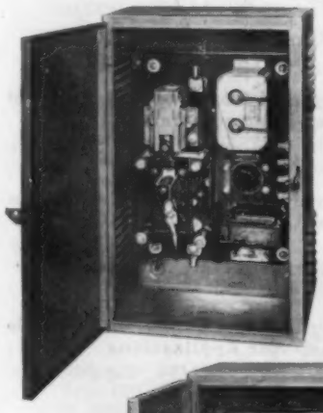
UNIVERSITY RESEARCH CONFERENCE

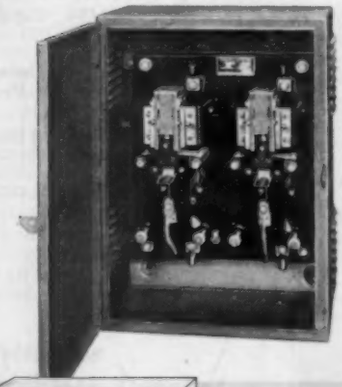
Announcing a new

Electronic WELDER CONTACTOR

SQUARE D COMPANY
INDUSTRIAL CONTROLLER DIVISION
MILWAUKEE, WISCONSIN, U.S.A.

- Generous wiring space.
- Removable steel base plate.
- Heavy steel cabinet with drain holes and louvres.
- Flat door for close ganging.
- Control elements grouped away from tubes and cables.





With Three Complete Lines Square D has the right contactor for each resistance welding job

Electronic contactors for jobs involving heat control, very short weld periods at heavy currents, or exceptionally high speed operation.

SYNCRO-BREAK contactors for production jobs where lower installed cost and economical operation are important. Especially desirable where welders must operate over a wide range of weld times and duty cycles. Synchronizing feature eliminates arcing and prolongs contact tip life.

HIGH SPEED contactors, single or two-pole, for greatest economy on jobs where loads are smaller and duty cycles less severe. Designed specially for welder service, with knife-edge bearings, low-inertia moving parts and powerful blowout coils.

Write for BULLETIN 8990, describing all three lines of contactors. Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin.

Square D builds *Safront* weld and sequence timers suitable for use with any of the three contactor designs. Write for BULLETIN 8991.

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

WEDNESDAY, NOVEMBER 20th, Morning—9:30 A.M.

THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
CUTTING

Chairman—JOHN J. CROWE, Air Reduction

Vice-Chairman—A. B. GORDON, The Linde Air Products Co.

Automatic Oxyacetylene Operations
by S. D. BAUMER, Air Reduction

Heavy Cutting Applications in Foundry and Steel Mill
by R. S. BABCOCK, The Linde Air Products Co.

Stainless Steel Cutting
by HOWARD HUGHEY, Air Reduction

VENETIAN ROOM
RESISTANCE WELDING

Chairman—O. C. FREDERICK, General Electric Company

Vice-Chairman—JOHN CUMBERLAND, Arcway Equipment

Additional Timing Period of New Motor Driven Control Increases Gun Welder Speed
by H. I. STANBACK, Square D Company

Radiography and the Fatigue Strength of Spotwelds in Aluminum Alloys
by ROBERT C. McMASTER and HORACE J. GROVER, Battelle Memorial Institute

Resistance Welding
A General Electric film to be shown by L. D. T. BERG, General Electric Co.

CLUB 22
STRUCTURAL

Chairman—F. H. FRANKLAND, Consulting Engineer

Vice-Chairman—W. E. HENDRICKS, Belmont Iron Works

H-Section Welded Trusses
by A. T. WAIDELICH, The Austin Co.

Welded Pier Leg, Shear Leg and Trolley of a 15-Ton Ore Bridge
by GEO. F. WOLFE, Dravo Corp.

Recent Trends in Concepts of Design for Welded Steel Structures
by LaMOTTE GROVER, Air Reduction

Wednesday Afternoon—2:00 P.M.

THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
RESISTANCE WELDING

Chairman—K. W. OSTROM, K. W. Ostrom & Company

Vice-Chairman—E. S. ELWOOD, The Denton & Anderson Co.

Choice of Cable and Transformer Size for Portable Spot Welder
by MYRON ZUCKER, Mackworth G. Rees, Inc

Three Phase Balanced Load Resistance Welding Machines,
by MARIO SCIAKY, Sciaky Brothers

The Flash-Welding of Hard-Drawn High Carbon Steel Wire
by R. W. BENNETT and R. D. WILLIAMS, Battelle Memorial Institute

VENETIAN ROOM
CUTTING

Chairman—J. H. ZIMMERMAN, The Linde Air Products Co.

Vice-Chairman—JOHN D. BERT, Philadelphia Navy Yard

Arc Oxygen Cutting on the Surface and Underwater
by CHARLES KANDEL, Craftsweld Equipment Corp.

Powder Cutting and Scarfing of Oxidation-Resistant Materials
by D. H. FLEMING, The Linde Air Products Co.

Some Recent Canadian Contributions to Oxygen Cutting, and Film "No Keener Blade"
by R. A. DUNN, Canadian Liquid Air Company, Ltd.

Oxygen Cutting of Steel at Elevated Temperatures
by I. F. KIERNAN and J. S. SOHN, Air Reduction

CLUB 22
WELDING ALLOY STEELS

Chairman—R. D. THOMAS, JR., Arcos Corp.

Vice-Chairman—A. A. HOLZBAUR, Sun Shipbuilding Co.

Investigation of the Weldability of Copper-Bearing Steels
by N. H. KEYSER and C. H. LORIG, Battelle Memorial Institute

The Control of Weld Hot Cracking in Nickel-Chromium-Iron Alloys
by T. E. KIHLGREN and C. E. LACY, The International Nickel Co., Research Laboratory

Welding of High Tensile Alloy Steels in Post-War Applications
by HOWARD L. MILLER, Republic Steel Corp.

Navy-E.E.S. Method for Determining the Applicable Welding Procedures for Steels
by BELA RONAY, U. S. Naval Engineering Experiment Station

Wednesday Evening—8:00 P.M.

RENAISSANCE ROOM
SECTION ACTIVITIES

Chairman—F. W. DAVIS, Chairman, Section Advisory Committee

Vice-Chairman—J. F. MAINE, Past Chairman, Cleveland Section

Section Officers will hold their Annual Dinner in the Venetian Room at 6:30 P.M. and Meeting to be followed by a special open session on Section operation involving presentation of papers and discussion by Section Representatives

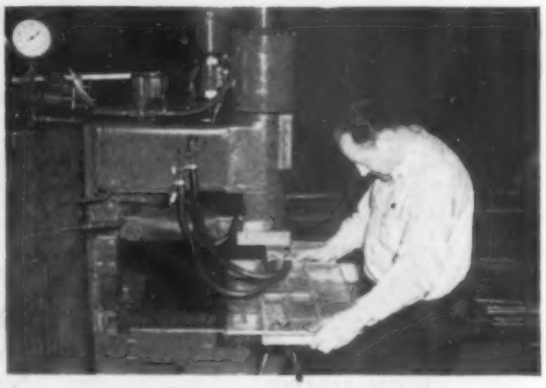
1 to 18 wire welds on the same welder!

3 simultaneous spots weld .050" channel to .225" wire frame on these refrigerator trays.

Wire trays for refrigerators, ovens, kitchen cabinet shelves and many other uses are being produced *at the rate of 2,000 per hour* at the modern plant of the L. A. Young Spring and Wire Corp., Detroit.

A recent installation of 14 Sciaky 250 KVA projection welders helps maintain this impressive production record. An outstanding characteristic of these machines is *flexibility* . . . the same welder can accommodate many jobs with only a simple change in dies and settings.

If your problem involves joining wire in one or many operations, it will pay you to investigate this rugged, versatile welder. Ask for a SCIAKY application engineer.

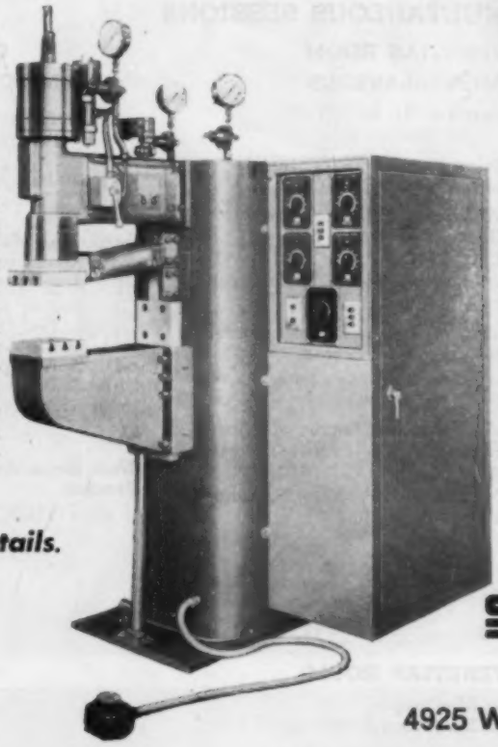


9 cross wires of .032" stock are welded to an .307" trim section in one operation.

Handles are welded to refrigerator tray with two simultaneous spots. (Majority of material is 18-8 stainless steel.)

Specially Designed for use in the Wire Industry

This projection welder (type PMCO 1-250-18) is rated 250 KVA at 50% duty cycle. Capacity is from two 1/16" basic steel wires up to and including eighteen 11-gauge wires. Stepless heat adjustment is provided by *both* tap switch and phase shift. Complete electronic controls insure balanced circuit, cleaner, faster welds.



Write for Complete Details.

SCIAKY BROS. Inc.

4925 W. 67th St. Chicago 38, Ill.

THURSDAY, NOVEMBER 21st, Morning—9:30 A.M.

THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
PRESSURE WELDING

Chairman—A. B. KINZEL, Union Carbide & Carbon Res. Labs.

Vice-Chairman—A. T. LIGHT, York Corporation

Open Butt Oxyacetylene Compression Welding
by H. H. CHISWIK, Air Reduction

Pressure Welding of Low Alloy Steels and Some Non-Ferrous Alloys
by K. H. KOOPMAN, Union Carbide and Carbon Research Labs., Inc.

Welding of Stainless Steel Rings
by C. J. BURCH, The Linde Air Products Co., A. L. RUSTAY, STEPHEN JABLONSKI and ALAN CROWELL, Wyman-Gordon Co.

Pressure Gas-Welding of Alloy Steel Tubing
by Z. L. ZAMBROW and R. D. WILLIAMS, Battelle Memorial Institute

VENETIAN ROOM
AIRCRAFT

Chairman—G. S. MIKHALAPOV, Air Reduction

Vice-Chairman—P. H. MERRIMAN, The Glenn L. Martin Co.

Design and Production Control Silver Alloy Brazed Joints in Aircraft Structures
by H. A. SMITH, and P. A. KOERNER, Beech Aircraft Co.

Resistance Welding Test Methods Used to Maintain Quality in the Manufacture of the 140 Jet Engine
by P. G. PARKS, Solar Aircraft Co.

Welding Problems in Jet Propulsion—Stainless Steel
by E. J. DeWITT and MR. LAMMERS, Wallace Supplies Mfg. Co.

CLUB 22
HARD FACING

Chairman—A. V. HARRIS, Haynes Stellite Co.

Vice-Chairman—M. W. BREWSTER, Westinghouse Electric Corp.

Repairing Contractors and Steel Mill Equipment with Manganese Application Bars
by L. A. DAVIS, Manganal Div., Stulz Sickles Co.

How to Select Wear Resisting Alloys for Welding
by JOSEPH A. CUNNINGHAM, J. A. Cunningham Equipment, Inc.

Microstructure of Hard Facing Alloys
by H. W. SHARP, Stoody Co.

Composite Construction by Building Up Surfaces with Submerged-Melt Welding
by J. E. TAYLERSON, The Linde Air Products Co.

Thursday Evening—7:00 P.M.

RENAISSANCE ROOM

DINNER

PRESENTATION OF MEDALS AND PRIZES

Chairman—WENDELL F. HESS, President, American Welding Society

Vice-Chairman—E. V. DAVID, Chairman, Convention Committee

FRIDAY, NOVEMBER 22nd, Morning—9:30 A.M.

THREE SIMULTANEOUS SESSIONS

RENAISSANCE ROOM
HIGH ALLOYS

Chairman—R. D. THOMAS, SR., Arcos Corp.

Vice-Chairman—E. R. McCLUNG, Lukenweld, Inc.

An Attempt to Select a Suitable Specimen for the Study of Corrosion Cracking in 18-8 Steel
by D. S. McKINNEY, Carnegie Institute of Technology

Welding and Other Fabrication Methods for Hastelloy Alloys
by C. G. CHISHOLM, Haynes Stellite Co.

Effect of Alloying Elements on the Tensile Properties of 25-20 Weld Metal
by HALLOCK C. CAMPBELL and R. D. THOMAS, JR., Arcos Corp.

VENETIAN ROOM
MISCELLANEOUS

Chairman—H. B. SEYDEL, Air Reduction

Vice-Chairman—G. R. JOHNSON, The Lincoln Electric Co.

The Arc Welding of Cast Iron with Nickel Electrodes
by T. E. KIHLGREN and L. C. MINARD, The International Nickel Co., Research Laboratory

The Welding of High Temperature, High Pressure Steel Valves
by VINCENT MALCOLM, Chapman Valve Company

Static and Fatigue Tests of Arc-Welded Aluminum Alloy 61S-T Plate
by E. C. HARTMANN, MARSHALL HOLT and A. N. ZAMBOKY, Aluminum Research Laboratories

CLUB 22
MISCELLANEOUS

Chairman—G. V. SLOTTMAN, Air Reduction

Vice-Chairman—L. D. T. BERG, General Electric Co.

Submerged-Melt Welding of Corrosion-Resisting Metals
by H. J. ROBERTS, The Linde Air Products Co., and R. J. ANDERSON, Dominion Oxygen Co., Ltd.

Production Applications of Inert-Gas-Shielded Arc Welding
by H. T. HERBST, The Linde Air Products Co.

A New Semi-Automatic Arc Welding Process
by J. M. TYRNER, Air Reduction

Friday Afternoon—2:00 P.M.

VENETIAN ROOM

Business Meeting—2 P.M.
Board of Directors Meeting—3 P.M.